YEARLY SUBSCRIPTION $6.00 SINGLE NUMBERS $1.00

FEB 7 1921

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

THE AMERICAN JOURNAL OF ROENTGENOLOGY

OFFICIAL ORGAN OF THE
AMERICAN ROENTGEN RAY SOCIETY

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VOLUME VIII NUMBER 1

January, 1921

PUBLISHED MONTHLY BY PAUL B. HOEBER
NEW YORK CITY

MIDWINTER MEETING EASTERN SECTION AMERICAN ROENTGEN RAY SOCIETY, HADDON HALL-CHALFONTE, ATLANTIC CITY, JANUARY 28, 29, 1921.

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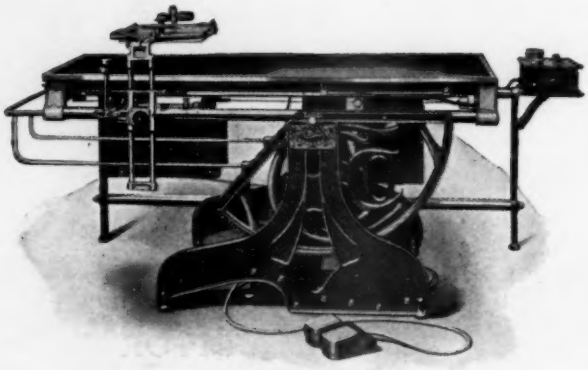

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor, H. M. Imboden, M.D., New York

VOL. VIII (NEW SERIES) JANUARY, 1921 No. 1

PERISTALSIS IN HEALTH AND DISEASE*†

FIRST CALDWELL LECTURE

BY WALTER C. ALVAREZ, M.D.

Assistant Professor of Research Medicine, George Williams Hooper Foundation for Medical Research, University of California Medical School

SAN FRANCISCO, CALIFORNIA

MR. PRESIDENT, Members of THE AMERICAN ROENTGEN RAY SOCIETY: I wish first to thank you for the great honor you have done me in asking me to give the first Caldwell Lecture. It is a pleasure to join with you in remembering the name of one of the martyrs of medicine—a man who gave his life for the advancement of science. He was a pioneer, an inventor, a research worker, a versatile, enthusiastic and lovable man; and we are all losers by his death. We shall honor him best by carrying on the work which he loved so much, and which meant everything in life to him. I believe we shall carry it on most rapidly when we do as he did, when we venture out into "pure" science —into physics, chemistry and engineering, to improve our apparatus; and into biology, physiology and bio-chemistry to explain our findings in the body. How much more rapidly our transformers and tubes would have been improved if there had been more men like Caldwell at work in the field; and how glad we should be to-day that some manufacturers have at last seen the incalculable benefits that can come through proper cooperation with a physicist like Dr. Coolidge!

Every advance in technique brings its problems of interpretation. I shall never forget my delight when, in 1912, I got my first radioscope from Vienna and saw the peristaltic waves coursing over the stomach. At first it seemed as if all my desires had been fulfilled, but in a few months this feeling of satisfaction gave way to one of worry over the many things which I saw but could not interpret. I went East and told my troubles to Cannon, who frankly admitted that many of our pathologic findings are not explainable on the basis of the myenteric reflex or the acid control of the pylorus. He gave me room in the laboratory and told me to go to work on these problems myself. He showed me how to open an (anesthetized) animal's abdomen under salt solution so that I could watch the peristaltic movements. Two or three days of this and I saw that the problems I had set for myself were too big and too complicated. I was like a man who would repair a wireless telephone without first knowing the structure and inner workings of the constituent batteries, induction coils, condensers and magnets. It was clear that I had to begin back near the beginning, on prob-

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

† This lecture will be published complete in book form by the publisher of THE AMERICAN JOURNAL OF ROENTGENOLOGY.

lems which to an onlooker might appear to have no promise of practical value. The intestine is a tube made up of smooth muscle and it seemed to me that if I could learn more about the properties and peculiarities of that tissue I would come near to solving some of the riddles of peristalsis. Hence it is that for the last seven years I have turned somewhat aside from the clinical journals and have delved into the literature of the experimental zoologists, the physiologists and the comparative anatomists. I have studied smooth muscle in organs other than the bowel—in the bladder, the ureter, the vas deferens, the uterus, the arteries and the iris. Many helpful suggestions have been gotten from studies on snails, sea-cucumbers, anemones, jelly fishes, clams, worms and crayfishes. I have found the medical indexes almost useless in this work, because the most helpful articles are often concealed behind the most uninviting titles. Thus, who would have expected to find an explanation for the gastric upsets of fevers and asthenic states in an article on the swimming plates of a tiny water organism?—yet there I believe it is. The author is Professor Child, a zoologist, and the article is entitled, "The Gradient in Susceptibility to Cyanides in the Meridional Conducting Path of the Ctenophore Mnemiopsis." [1]

It is unfortunate that we practicing physicians must often miss the most thought-stimulating articles because they are buried away in the highly technical journals which we do not ordinarily read. Some day we may have a better abstracting service, but in the meantime we shall probably have to do occasionally as the Israelites did when they approached the Promised Land; we shall have to send out spies to look over this field which we ourselves have so little time to explore, and to bring back some of the fruits. When asked to speak before you to-day, it seemed to me that the best service I could render would be to bring to you some of the ideas which I, a practicing physician and radiographer, have gotten during my sojourn among the physiologists.

THE AUTONOMY OF MANY PARTS OF THE BODY

The first of these ideas is that *the forces which bring about, modify and control peristalsis must be looked for mainly within the walls of the gut itself*. I cannot too strongly emphasize this point, because it seems to me that the failure to grasp it is the greatest stumbling block to further advance in the knowledge of our subject. Whenever I describe some of the regional differences in behavior which can easily be demonstrated in the excised stomach and bowel, someone is almost sure to say: "Oh, that is due simply to the autonomic and the sympathetic." Another settles the whole problem by calling it a "Reflex." When I point out that the peculiarities persist in little pieces of muscle which have been cut out and kept in the ice box for several days, these individuals still ascribe everything to the activities of the canny little ganglion cells in Auerbach's plexus.

Now, the most paralyzing thing in scientific work is a facile explanation which puts a stop to further curiosity without really advancing our knowledge of the subject; and I have never been able to see the value of pushing the explanation for a mechanical phenomenon out of the organ in which it might be studied, and into a tiny ganglion where we can hardly follow it. It seems to me that many even of the teachers of physiology have a wrong idea of the nervous system and its relation to the viscera. They look at it somewhat as an electrical power house which not only supplies the motive force but controls the activities of the various trains running over a railroad. My analysis of the literature makes me feel that we should look at it more as a telephone switchboard with wires which carry nothing but messages of warning and advice from one engineer to another. The trains supply their own power; and the differences in speed and other activities are due to peculiarities in fuel, differences in the gradient of the road, etc.

Anyone who will study the behavior of the lower forms of life before and after removal of their nervous systems will see that the nerves are there primarily to expedite conduction. The ganglionic cells are nutritional centers and not storehouses of wisdom and power. Some of the most complicated "reflexes" are performed by decerebrate animals or by excised parts of these animals. Loeb, Parker and others have shown clearly that the mechanisms are local and comparatively simple.

THE MYOGENIC NATURE OF THE RHYTHMIC CONTRACTIONS

Similarly, in the gastro-intestinal tract we find that after the preliminary shock has worn off, digestion goes on quite normally after complete section of the vagi and the splanchnics. We get good peristalsis in the stomach and intestine that have been removed from the body and either perfused or placed in oxygenated Locke's solution. We get active peristalsis in small segments of gut and in pieces of muscle stripped from the wall. It is clear then that the gastro-intestinal tract is autonomous: it carries within itself all the mechanisms essential to peristalsis.

The next question is, what part is played by the muscle and what part by Auerbach's plexus? Practically all writers on the subject state that the rhythmic contractions are due to stimuli coming from the ganglion cells of the plexus. They base this opinion on the first few papers by Magnus, who found that strips of circular muscle from which the plexus had been removed did not contract rhythmically. Unfortunately no one seems to have noticed that in his fifth paper,[2] Magnus admits that these same plexus-free strips did beat when he added a little physostigmin, strophanthin or barium to the solution. Moreover, no one notices the work of Gunn and Underhill[3] who repeated these experiments, and by taking greater precautions to avoid trauma, obtained plexus-free strips which would contract rhythmically without the help of tonic drugs. This is what we should expect, because it has been well proven in many ways that rhythmic contraction is a function of muscle itself.

It is clear then that the man who would understand peristalsis and the various activities of the stomach and bowel must pay particular attention to the properties and reactions of the gastro-intestinal muscle. Some may ask: what then is Auerbach's plexus good for? It almost undoubtedly serves for the conduction of stimuli and the coordination of movements; it enables the muscle to respond properly to stimuli coming from the underlying mucous membrane, and it helps in some way to keep that muscle from contracting down into a hard knot. Such contractions are well known to biologists, and somewhat resemble the spastic paralyses of striated muscles.

THE AUTONOMIC AND THE SYMPATHETIC

The next question is: what is the significance of the vagus and sympathetic nerves running to the intestine? The average clinical writer to-day states that the autonomic (vagi and sacral nerves) stimulate, and the sympathetic fibers inhibit the intestine. Disease is supposed to follow an unbalance between these two effects. This unbalance can be diagnosed and corrected by the use of certain drugs which are supposed to be elective in their actions. These theories of vagotonia and sympathicotonia have had a strange fascination for the medical mind; they have been dragged in with the utmost assurance to explain all sorts of disease states; and I believe have had a most unfortunate influence on our conceptions of gastro-intestinal physiology. It may be that these theories will eventually prove useful; but in my opinion their foundations are so shaky that some day the whole edifice is going to go. In the following brief discussion I can only point out a few places in which the proponents of these theories have made things much simpler than they really are.

Although in the main, the vagus tends to stimulate and the sympathetic to inhibit the stomach and bowel, these effects are generally transient, often indecisive and not infrequently reversed. They vary with the strength of the stimulus and with the condition of the muscle. The next objection is that the whole theory of "nerve endings" and "intermediate substances" is shaky. Leading pharmacologists have for some time been calling attention to the many contradictions in the literature of the subject, and have warned us to be careful in accepting physiologic conclusions based upon the supposed activities of the various nerve poisons.[4]

Perhaps the strongest objection to the recently revived theories in regard to the autonomic and sympathetic systems is that they make it appear that the sympathetic nerves with the celiac ganglia constitute a separate and distinct brain system which can be antagonistic to, or out of harmony with the central nervous system. This view is entirely at variance with the facts, which have been collected and discussed in a masterly way by Gaskell in his monograph on "The Involuntary Nervous System."[5] He shows that the involuntary nerves and ganglia are a part of the central nervous system; they are connected with it just as the voluntary nerves are, and they have developed from the same embryonic cells. The main difference is simply that the motor ganglia which in the voluntary system are found in the anterior horns of the cord, have migrated, some as far as the paravertebral ganglionic chain; some into the solar plexus, and some into the nerve nets in the walls of the hollow organs. Hence it is that the rami communicantes or preganglionic fibers in the sympathetic system, and most of the efferent fibers in the vagus are simply elongated connector neurones such as we find between the motor and sensory roots in the cord, and in the pyramidal tracts. Furthermore, it has been shown that there are no commissural fibers between the different sets of sympathetic ganglia such as would have to be present if these ganglia were to mediate reflexes like an abdominal brain.

VALUE OF THE EXTRINSIC NERVES

We learn then from Gaskell the same lesson that we have had from Loeb and from Parker: that the nerves are there to conduct, and not to exercise faculties requiring almost human intelligence. There are times when the animal as a whole needs to communicate with its digestive tract; there are times also when the tract must communicate with the body. There are many times when one end of the tract must communicate with the other; and on all these occasions the extrinsic nerves come into play. The vagi carry feelings of hunger and of satiety from the stomach to the brain; they help in adjusting the tone of the stomach wall to the food coming down the esophagus; and they carry the stimuli that give rise to the psychic secretion of gastric juice. If the food must be rejected by vomiting they carry the impulses which bring the abdominal muscles to the aid of the stomach. They probably carry messages from the digesting tract which make the animal feel comfortable and sleepy. The splanchnics serve largely to quiet the tract and to stop digestion when the body is distressed or injured. The extrinsic nerves probably have much to do with the digestive upsets with disease elsewhere in the body; but we shall see later that these changes can be accounted for also by actual damage to the gastro-intestinal muscle.[6]

I regret that I have had to spend so much time on this subject of nervous control; but it seems that the human mind is not so ready to look for new explanations for well-known phenomena, or even to accept them when found, until its contentment with the old explanations has been disturbed. Now that we see how autonomous the tract is and how dangerous it is to rely on theories of ganglionic control, we should be the more eager to learn all we can about the gastro-intestinal muscle.

SMOOTH MUSCLE

As you know, smooth muscle is made up of spindle-shaped cells which vary in size, shape, number of nuclei, etc., in different animals and in different parts of the same animal. As a rule it contracts more sluggishly than striated muscle does; it takes longer to get started, and it is slower in recovering its original length. After a number of strong stimuli or sometimes after only one, it may become quite refractory. After a long rest it may seem to get on a hair trigger again so that it responds powerfully and explosively to a slight stimulus. That is the condition of the digestive tract after the night's rest; and it probably has much to do with the fact that most of us have the daily bowel movement in the morning, immediately after breakfast. With an animal open under salt solution, one can often start a rush wave down the bowel by pinching the duodenum. For some time afterwards, similar pinches will have no effect, but if we wait long enough we will again find the bowel so sensitive that the slightest stimulus will start a wave.

Another characteristic of smooth muscle is its ability to maintain a firm and lasting contraction without fatigue. We see this in the muscles which close the shells of bivalves and we see it in the wall of the colon. It is interesting that the muscle in a bivalve consists of two parts: one which closes the shell and the other which locks it closed. By cutting first one and then the other it can be shown that neither one can do the work of the other. Similarly, if one of you will try to hold his arm out perpendicularly to his body he will soon find it a most painful and fatiguing experiment. The deltoid was not designed for such heavy work, but the glutei and back muscles are carrying much heavier loads all day, and they do not complain. There are all kinds of muscles, all suited to different purposes. Some, like those in the wings of insects, must contract 300 times a second; others like those in the wings of a hen have little to do. Those who think all muscle is the same forget the differences between the white and dark meats of chicken, between the heart and the gizzard; between the tenderloin, roundsteak and tongue. I have gone into these differences so at length to prepare you for the thought that there are big differences between the muscle in the cardiac and pyloric ends of the stomach;[7] between that in the small intestine and that in the cecum [8] and colon.[9] The muscle on the lesser curvature near the cardia is soft to the touch like coagulated fibrin; that in the pyloric antrum is tough like gizzard and has a different color. Stimulate the two with an electric current or with a pinch and you get two entirely different contraction curves; put them into warm oxygenated Locke's solution and you get two different types of rhythmic activity. These differences were to be expected when we remember that the upper and lower ends of the stomach have different kinds of work to do. The upper end serves largely as a hopper to hold the food; the lower is the mill that does the heavy work. More of these local peculiarities will be described later.

Another characteristic of smooth muscle in hollow organs is its responsiveness to tension. Most of the manifestations of peristalsis are brought about and regulated largely by the internal pressure due to the presence of food or gas. Cannon has shown that the rhythmic segmentation in the small intestine is due simply to the fact that those muscle fibers which are stretched tend to contract.

Smooth muscle shortens also under the influence of direct irritation. Thus we find contraction of the cardia, pylorus, ileo-cecal sphincter and anus when there is ulceration or inflammation near by. We find hour-glass contractions of the stomach opposite ulcers on the lesser curvature; and shrunken and irritable duodenal caps with ulcers in that region.

PERISTALSIS

If we stimulate the smooth muscle in a tubular organ like the intestine or ureter, we

get a contraction which produces a tonic ring. From this ring, waves are given off in both directions. They remind one of the ripples which arise at a point where a stone has been thrown into a pond. The impulse spreads from muscle fiber to muscle fiber, and need not be mediated by nerves, ganglia, centers or reflexes. I have observed, after electrical stimulation, similar waves spreading both ways along the segments of a recently voided tapeworm; and I have seen them traveling away from the ridge which forms when one strikes the irritable pectoral muscles of a consumptive. It seems to me that the stimulus probably increases the chemical activity at the point where the tonus ring forms; it raises the metabolic rate, and stimuli spread out on both sides down gradients of chemical activity.

GRADIENTS

Returning to the simile of waves spreading in water, it seems to me that some tubular organs may be likened to ponds which are level to begin with; others are more like rivers which have definitely established gradients. In the first case the waves spread equally well in all directions; in the second, the waves spread better down stream than up. Perhaps I can illustrate my point best by showing the evolution of the fixed gradient in the heart. As you know, in that organ the beat follows a gradient of rhythmicity from the sinus to the ventricle. It was Gaskell who showed that if we cut a heart into three or four pieces the one containing the mouths of the great veins will show the greatest tendency to beat rhythmically, and will have the fastest rate. The ventricle will be slow to start beating and will have a slow rate. Now, when we turn to the primitive heart of the sea slug (aplysia), we find a tube which apparently has no constant gradient in either direction. Its beat arises now on one side and now on the other, depending on where the blood produces the greatest tension. Hunter could find no sign of a gradient in the heart of one of the ascidians. In these animals the beat runs for a while towards the viscera and then for a while towards the gills. The pace-making end seems to get fatigued; its rate is slowed and finally the other end is able to assume the pace for awhile. A constant direction of contraction may be maintained by electrical stimulation of either end of such a heart. It seems to me that Hecht's [10] studies on ascidia atra show us the very beginning of the fixed gradient which we find in the hearts of the higher animals. He found that although the heart of the ascidian reverses its beat from time to time, the sum of the advisceral beats is about twice that of the abvisceral. Moreover, as we should expect if the gradient is a little better in the advisceral direction, the rate of conduction is definitely faster in that direction than in the other. If a wave is started in the middle of the heart going both ways it tends to efface the abvisceral waves which according to our theory would have the smaller momentum. It is interesting also that under slightly adverse conditions, as after warming the water or after diluting or concentrating it, it is the abvisceral beat which is suppressed. We find a little more stable, but still reversible heartbeat in the sharks and rays. In them the slightest stimulus to the bulbus aortae will reverse the beat and the same stimulus to the sinus will restore it. Even in the higher vertebrates the heartbeat can be reversed temporarily by agencies which lower the rhythmicity of the auricle or raise that of the ventricle.

There is considerable evidence now that peristalsis in the ureter follows a gradient of rhythmicity from the kidney to the bladder,[11] and I have been collecting data which suggest that there are similar gradients in the vas deferens and the fallopian tubes. We may perhaps be able later to state it as a law that the direction of transport of material in a tubular organ depends on gradients of rhythmicity, tone, irritability and metabolism. When we come to think of it, our experience with engineering and mechanics should have led us long ago to look for gradients in these muscular tubes. We know that

water in a pipe follows gradients of gravity or of pumping pressure; electricity flows along gradients of voltage, the winds follow gradients of barometric pressure, etc.

GRADIENT IN THE INTESTINE

Now what evidence have we that there is a gradient in the gastro-intestinal tract? As far as rhythmicity goes the evidence is overwhelming. It is a simple thing to open an animal (rabbit) under salt solution and to demonstrate that the rate of rhythmic contraction varies from about 20 per minute in the duodenum to 10 per minute in the lower ileum. It is easy also to cut out short segments of the bowel and to show that their rate of rhythmic contraction continues to vary inversely as the distance from the pylorus. A similar gradient can be shown in strips of muscle excised from the wall of the stomach. The fastest rate is found in the strip from the lesser curvature near the cardia. It is harder to show the gradient in the colon, but that was to be expected. Remember that the large bowel is more sluggish than the small; it lets the contents lie in one place for long periods of time and waves can go in either direction over the cecum and ascending colon. Hence it is that the excised muscle is slow to start beating, its rate is slow; it tends to contract down into a hard knot and stay that way; and the gradient is poor and often reversed. In the small intestine of the rabbit and white rat the rhythmic gradient is so fixed, and so intimately "built into" the structure of the intestine that one can determine the oral and aboral ends of short excised segments by counting the rates at the two ends. It has been shown also that when sections of small intestine are cut, turned end for end and anastomosed again, they will transport liquids but not solids, because the original direction of peristalsis is maintained as long as the animal lives. This experiment shows that the gradient is basic and not the result of functional adaptation. Further evidence for that conclusion is found in the fact that it is just as marked in the fetal intestine, which has not yet functioned, as in the adult animal. The permanence of the gradient in the gut is to be expected from studies on the lower forms of life. The mouth of a frog is lined by epithelium covered with little cilia which wave in one direction. If a piece of this epithelium is cut out, turned through an angle of 180°, and grafted back again, the cilia continue to beat in their original direction, now contrary to that in the rest of the mouth. In some of the worms the so-called "polarization" is so perfect that if the animal is cut into a half-dozen pieces they will all crawl in the same direction towards the point where the head used to be.

Before leaving the topic of rhythmic contraction I must make it clear that in the intestine the rhythm of one segment rarely influences the rhythm of the adjacent ones. As you know, in the heart the region with the fastest rate sets the pace for all others, and the wave of excitation travels so rapidly that to the naked eye the mammalian heart appears to contract simultaneously all over. In the stomach, the area with the most rapid rate at the cardia sets the pace, and we can see the waves traveling slowly to the pylorus. In the small intestine each segment contracts at its own rate and only occasionally do we see what are called peristaltic rushes running any distance down the bowel. Although the duodenal muscle has the fastest rate it does not set the pace for the rest of the gut. I must emphasize this point because some writers in overlooking it, have theorized unwarrantably on the basis of some purely anatomical observations reported by Keith.

UNDERLYING BASIS OF THE RHYTHMIC GRADIENT

The next question is: how are these differences in rate brought about? What are they due to? What are the structural differences behind them? As we have seen that these rhythmic movements are myogenic in origin, it is plain that we must look for the differences in the muscle. Now, it has been

shown that the rate of rhythmic contraction is probably dependent upon the rate at which the chemical processes go on. Some substance is built up to a certain point and then exploded to produce the contraction. If the metabolism is slow it should take longer to complete the cycle. We know also that warming hastens chemical processes, and Taylor and I have shown that warming the intestine hastens the rate of rhythmic contraction. As we can take a piece of ileum beating 10 times a minute, and by warming it speed up its metabolism so that it will beat 17 times per minute, it seems to me that the duodenum which normally beats 17 times per minute must have a faster metabolic rate than the ileum. Such differences in metabolic rate have been demonstrated in other organs of the body, where they appear to have great significance.[12] During the last few years Miss Starkweather and I have brought forward a good deal of evidence to show that there is a gradient of oxidation from the cardia to the pylorus, from the duodenum to the ileum and from the ileocecal sphincter to the anus.[13] For the unit of weight and time the muscle from the duodenum gives off more CO_2 than does the muscle from the ileum. This is true not only for the active but also for the resting muscle. Graded differences have been found, moreover, in the catalase content of equal weights of minced muscle. This catalase, which liberates oxygen from hydrogen peroxid, is supposed by some to be an index of the rate of metabolism; and certainly in the bowel the gradients of CO_2 production and catalase activity run very close together. Be that as it may, the interesting thing to me is that we can show a definite chemical difference between the muscle in the duodenum and that in the ileum.[1]

We know that there is some gradation also in the irritability of the intestine as regards distension. The duodenum and jejunum are very responsive to the presence of food or balloons, while the lower ileum and colon are quite tolerant of them. You all know that the barium meal in the jejunum appears in small flecks as if it had been sprayed over the folds of the mucous membrane. In the ileum it forms dense sausage-shaped masses. That is due simply to the greater irritability and activity of the upper bowel.

Hess showed years ago that the pull exerted by the jejunum of a dog on a small balloon is 228 gm., while in the ileum it is 75 gm. Naturally, the food is going to move from the active and irritable regions to the more sluggish and insensitive ones. I cannot conceive of a simpler theory of peristalsis, or one more in harmony with the laws of physics and mechanics.

DIFFERENCES IN PERISTALSIS IN DIFFERENT PARTS OF THE GUT

Let us follow for a few moments the progress of a barium meal through the digestive tract, noting how the peristaltic movements are influenced by local differences in structure and musculature. The mouthful shoots through the first part of the esophagus because the muscle is quick-acting and striated. In the lower third the muscle is largely of the smooth variety and progress slows up. In the stomach the waves begin probably in the pacemaking region near the cardia and travel as shallow ripples until either proper pressure conditions or the presence of the peculiar antral muscle causes them to break into deep waves. If the tone of the stomach is too high the waves may be very shallow or hard to see; if the tone is poor, we may see the best waves at the beginning of the examination when there is only a little food present and the muscle fibers are not too badly stretched.

The waves do not cross the pylorus, probably because of the connective tissue barrier there, the peculiar arrangement of the muscle fibers, and the sudden transition to a different type of muscle. The control of the pylorus is partly chemical and partly mechanical. Cannon has shown that the presence of acid above tends to relax the sphincter and acid below tends to close it. We know

however that this mechanism will not explain the vagaries of pyloric action in achylia gastrica, in duodenal ulcer, carcinoma, etc. We know also that the mere presence of food or of a distending balloon in the duodenum and jejunum will tend to stop the progress of food through the pylorus.[14] It is this mechanism that keeps the stomach from emptying too rapidly after pylorectomies, Mayo-Polya operations and gastro-enterostomies. This holding back above an active or distended part of the gut is easily explained on the basis of changes in the gradient. The digesting, stretched bowel has a faster metabolic rate and a more rapid rate of rhythmic contraction; hence the gradient is likely to be uphill towards it. This will tend to slow the progress of more food coming down from above.[15]

The duodenal cap remains filled and shows almost no peristalsis, probably because the muscle removed from that region shows very little rhythmicity. There is some evidence that the muscle fibers are arranged in festoons and not circularly and longitudinally, as they are elsewhere. This might also tend to modify the contractions. I think the peculiarities of the upper duodenal regions, together with a number of its pathological tendencies, can be traced back to the great specialization and complexity of this part of the bowel in some of the fishes.

As I have already stated, the jejunum is jejune or empty because of its great irritability and rapid peristaltic rate. The food slows up in the terminal ileum because the muscle is more sluggish and because the gradient is uphill for a short distance to the ileocecal sphincter.

In the first third of the colon the gradient is poor, so that the waves can go in either direction. In the rat they tend to be antiperistaltic when the feces are liquid and peristaltic when the feces become drier. The colonic contents move slowly because the muscle is more sluggish and perhaps because the gradient is poor. The tendency for the feces to stay out of the rectum can be explained if I am right in thinking that the gradient is uphill in that region. There is some evidence from animal experimentation in favor of that assumption.[16]

PRACTICAL VALUE OF THE GRADIENT THEORY

This idea of a gradient underlying peristalsis gives us facile explanations for many of the phenomena observed in disease. The gradient of forces can be steepened, flattened or reversed. A duodenal ulcer which raises the irritability and tone of the upper end of the tract often hurries the progress of food through the small intestine; a lesion in the appendix or cecum which raises the irritability of the lower end of the bowel slows the current and produces ileal stasis. A fissure in the rectum may cause back pressure into the cecum with constipation. A patch of enteritis in the jejunum can reverse the current above, in the duodenum and stomach—with vomiting; and can hurry it below—with diarrhoea. A stimulus reaching the jejunum from the brain by way of the vagi—as in sea-sickness—may also empty the tract both ways. The distension of any part of the tract by food raises the tone and irritability of that region and tends to hold back the material coming down from above.

Theoretically, the gradient can be reversed not only by raising the lower end, but by depressing the upper end. My observations on excised segments of intestine from distempered dogs and snuffling cats agree closely with those of Child on the lower forms of life in showing that the most sensitive regions, which have the fastest metabolic rates and the greatest need for oxygen, are injured most by asphyxia, by many drugs and by disease toxins. I have shown repeatedly that a poison can be administered in such dosage as to have no effect on the colon and ileum, while it paralyzes the duodenum and weakens the jejunum. Furthermore, exised segments of duodenum from a sickly rabbit may not contract at all in Locke's solution when similar segments from the ileum of that animal show no sign of toxic influence. A reversal or a flattening

of the chemical gradients can also be shown in many of the sick animals. We have here, then, an easy and very simple explanation for the digestive upsets with intestinal stasis which we see in fevers and asthenic states.

As I have discussed the practical aspects of my theory in previous papers [17] I will not go into the subject any further at this time. Remember, when confronted by an abnormality in intestinal peristalsis, that if the lesion is sufficiently irritating it will raise the local tone; this will reverse the gradient leading to the lesion on the orad side and it will steepen the gradient on the caudad side. Hence it is that it may slow, stop or reverse the progress of material coming toward it from above, and may hasten the progress of material that has passed it. Exceptions to this rule will be found around the stomach where there are many complicating factors not sufficiently understood at present.

In closing, I must admit that with all the work that has been done we still know too little about the origin of many of the disturbances of function which we see in our patients—the hypo- and hypermotilities, the sphincter spasms and the peculiarities in gastric peristalsis. We must keep in mind that we are using a physiologic method, borrowed from Cannon; we must think more in terms of deranged physiology, and must not rest too satisfied with the demonstration of beautiful morphologic defects—ulcer craters, carcinomas, adhesions and displacements. A number of you—practising radiographers—have made excellent physiologic studies on man; studies that are as much pure physiology as those of Cannon and Carlson. Much remains to be done; and if my little message from the biologists to-day should contribute anything to your zeal and skill in attacking these problems I shall be happy.

SUMMARY

We often fail in trying to solve our practical problems because we do not begin near enough to the beginning. We must know more about general principles and the workings of small parts of the digestive tube.

We must venture out more into "pure" science. We can get much help and inspiration from the experimental zoologists and the physiologists.

The digestive tract is largely autonomous, and the forces underlying peristalsis must be looked for mainly within the gut itself.

The tendency of writers to explain everything on the basis of nervous reflexes and ganglionic control is unfortunate, and paralyzing to further progress.

Recent biologic work has shown in numberless ways that the main function of the nervous system is conduction.

It has been shown conclusively that the rhythmical contractions of the intestinal muscle are myogenic in origin.

Auerbach's plexus serves to conduct stimuli and to coordinate the activities of different parts of the tract. It contains no reflex arcs.

Current theories about the antagonism between the vagus and sympathetic are shown to be pseudoscientific, and out of harmony with the facts as determined by the leading anatomists and physiologists of the world to-day. The sympathetic is an integral part of the central nervous system and not an outlying antagonistic "brain."

Many of the conclusions based upon the supposed actions of drugs on nerve-endings and "intermediate substances" must be revised in the light of recent work.

The extrinsic nerves of the intestine serve to communicate between the body and the bowel, and between the bowel and the brain.

The digestive tract can work quite normally after section of all the extrinsic nerves.

The key to an understanding of peristalsis is to be found in a study of the smooth muscle in the wall of the bowel.

There are different types of muscle suited to different functions in the different parts of the body and in different parts of the digestive tract.

The properties of smooth muscle are discussed: its reactions to stimulation, to distension, inflammation, etc.

A peristaltic wave spreads both ways from a stimulated spot like ripples from a stone thrown into a pond. Most of the muscular tubes are so constructed that the ripples can travel in one direction better than another.

It may perhaps be a law for all tubular organs that the transport of material in one direction depends upon gradients of rhythmicity, irritability, tone and metabolism.

Such gradients can easily be demonstrated in the walls of the stomach and intestine.

A bolus moves aborally in the digestive tract because the pressure is greater on the upper than on the lower side. This difference in pressure is due probably to the graded characteristics of the muscle.

The peculiarities of peristalsis in different parts of the tract are explainable on the basis of local differences in the structure of the neuromuscular mechanism.

It is shown how the gradients may be upset in disease, and how these theories can explain pathologic phenomena.

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PNEUMOPERITONEUM OF THE PELVIS*

GYNECOLOGICAL STUDIES—A PRELIMINARY REPORT

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A VERY fortunate and brilliant stereo set of the pelvis in a case coming from another ward was the means of interesting Dr. Reuben Peterson, Professor of Obstetrics and Gynecology at the University Hospital, in this study, and it is due largely to his hearty and enthusiastic cooperation that work was undertaken on this subject and the present series of cases made possible. He immediately suggested the possibilities of this method for the illustration of clinical lectures and the study of the anatomical relationship of the normal and pathological pelvis, quite aside from the possibility of the development of any diagnostic value. As a further piece of good fortune, one of the earliest cases provided such illuminating evidence, even though it was poorly understood at the time,that a serious attempt to develop the diagnostic feature of the method was projected.

At the outset it was agreed that if the method were to have any extended usefulness the technique must be at once safe, simple, certain and cheap; and throughout we have aimed to produce a method and a procedure which can be reduced to a routine and can be carried out by the assistants in the Department of Gynecology and the lay members of the radiographic staff. Naturally, our first efforts were far from simple and still farther from certain. In the interest of safety, Dr. Peterson agreed to attend personally to the inflations during the developmental stage, and to date we have examined somewhat over forty cases without any unexpected or disagreeable complications.

At the present time we have tentatively adopted the following procedure: The patients are inflated in the examining room in the Department of Gynecology immediately at the conclusion of the regular gynecological examination and on the regular gynecological table. The inflation is preceded by an injection of Schleich's solution and the point selected for puncture is usually about one inch below the umbilicus in the median line, unless previous operative scars, evidence of adhesions, or other pathology, contra-indicate.

Carbon dioxide is taken from one of the usual commercial tanks from which a nitrous oxide bag is filled, and this bag is then connected with the needle without intervening manometers or washing or sterilizing apparatus. During inflation, the bag is held between the knees of an assistant, thereby giving complete control over the pressure as well as giving a fair indication of the amount of gas which has been injected. We have found that from 1½ to 2 liters of gas are sufficient to produce a fair inflation of the pelvis, although in certain individuals the bowel coils can still be seen resting on the anterior abdominal wall in the most dependent portion of the belly.

The patient is then turned over on the face, being held in the knee-chest position until an inclined board can be placed beneath the thighs. This board makes an angle of about 28 degrees with the plane of the table and its upper portion is cut out and rounded so that the pubis comes to lie just about the deepest portion of the notch. An 18 inch square of opaque fabric with a 6½ inch circular hole cut out of its center is laid on

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

the buttocks and serves as a diaghragm. A plate changing tunnel is then placed horizontally on the table, double screen films are used, and a Coolidge portable unit, operating on the ordinary lamp circuit, furnishes the *x*-ray. An exposure of from fourteen to twenty seconds is required, and ordinarily each exposure is interrupted, being made at such intervals as the breath can be held conveniently, and the patient allowed to breath between the fractional exposures.

The tube shift is in the long axis of the body and the stereo set so produced is used as though the patient were lying on the right side.

This technique is the result of a series of progressive improvements. For instance, at first we used oxygen and brought the patients down to the *x*-ray room where they were first "screened" and then "plated." This method was entirely satisfactory from the *x*-ray point of view, but there was considerable complaint on the part of the patient for twenty-four or forty-eight hours if they attempted to move from the rigidly dorsal decubitus. Consequently a similar procedure was attempted with carbon dioxide; but it was found that if there were any unusual delay in the transportation of the patient—over several floors and down at least two elevators—the amount of gas remaining in the peritoneal cavity was insufficient to secure satisfactory plates. The portable *x*-ray machine used in the gynecological examining room seems to be a perfectly satisfactory solution of this difficulty.

We have also found that not so large an amount of gas is necessary for the inflation of the pelvis as for a satisfactory examination of the abdomen as a whole. Provided the examination can be undertaken immediately, we now believe that from a liter to a liter and a half is sufficient to inflate a pelvis of ordinary size. However, in order to be certain that all the intestines which normally lie in the pelvis may have a chance to escape, we prefer to give two liters of gas wherever the patient does not complain too seriously.

In the earlier cases there was considerable complaint, on the part of the patients, of persistence of the pain and discomfort for twenty-four to forty-eight hours. Accordingly, deflation was practiced. Since the introduction of carbon dioxide, deflation has not been necessary, and patients inflated at about 11 o'clock in the morning have taken their noonday meal in the sitting posture with complete comfort and no more reports of sleepless nights have been encountered. This is undoubtedly due to two factors: first, the more rapid absorption of carbon dioxide; and, second, to the smaller quantity of the gas introduced in the later cases. While discomfort and a sense of oppression are a constant complaint, these are not important except in cases with serious pathology in the upper abdomen or (as we suspect) with adhesions to the parietal peritoneum in the abdomen or pelvis.

For a time we introduced a short narrow helix of wire into the vagina for the purpose of simplifying the recognition of the various shadows in the pelvis by reason of the better differentiation which would result from a demonstration of the axis of this cavity. The shadow of the fundus of the uterus which in the earlier experiments was apt to be hidden in the shadow of the bladder, was thereby thrown backwards and more nearly into the axis of the pelvis and was more clearly outlined. However, because of the distortion which was introduced by the inflation of the vagina and the bulging of the posterior vaginal wall into the cul-de-sac of Douglas—almost invariably to one side of the median line—and because of the resulting distortion of the position of the uterus, this procedure has been discontinued.

It is probably superfluous to speak here of the advantages of the stereo set. However it is well to realize that the stereo effect in pelxis *x*-rays is not nearly so perfect as it is in the study of the bones or of the chest. The appreciation of depth is only possible when a definite point or a series of points is presented to the eye, establishing a definite parallax. In the case of a smoothly rounded soft tissue body of uniform density, such as we

are dealing with in the pelvis, such points are not normally found. The only lines upon which the eye can fix are the shadows of those portions of the perimeters of such bodies which are projected by rays which are tangent to the surface at these points. The depth of the fundus of the uterus appears, therefore, to lie in the position of its equator, and one gets no impression of the extent or the position of that organ above or the diffuse shadows of the abdomen. Our appreciation of the contour of this body is accordingly somewhat fragmentary and our conception of its shape may be quite erroneous. Nevertheless we believe the stereo set to be well worth while because of the ease with which the rather complex shadows of the pelvis may be resolved, the extraneous shadows excluded, and the relative position of these cross sections appreciated.

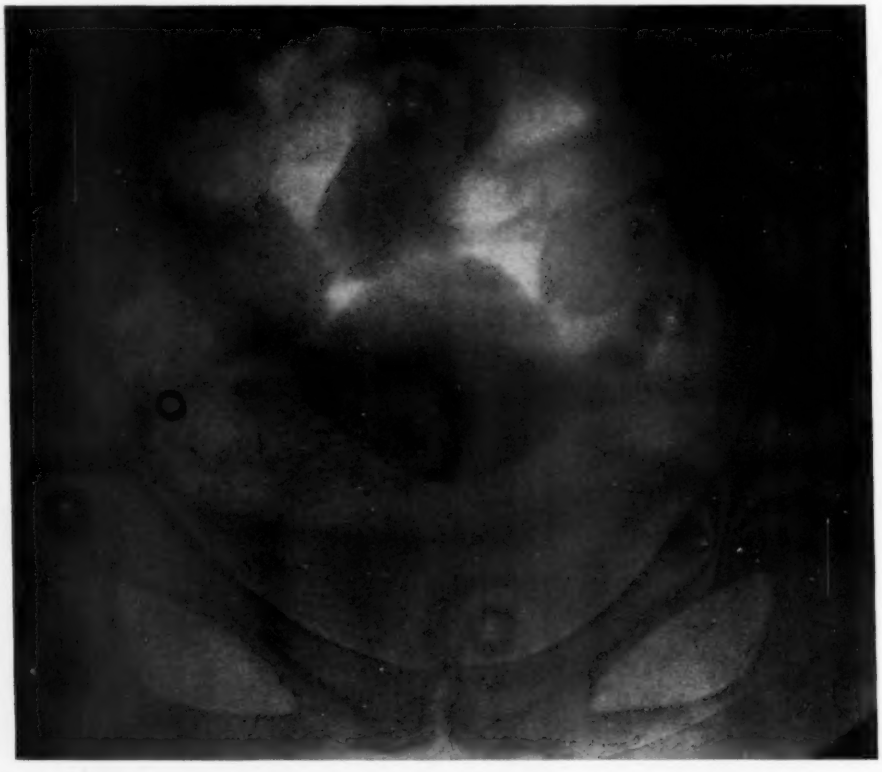

FIG. 1. NORMAL PELVIS. Note the optical cross sections of the isthmus and fundus of the uterus.

below that point. The image of an irregular body will be represented by a series of "optical cross sections" at the point of tangency of the projecting rays. For instance, the image of the uterus, four months pregnant, is represented only by the cross section of its enlarged cervical or supracervical portion (the isthmus) and by the shadow of the anterior surface of the neck just behind the pubis where it curves upward and extends into the abdominal cavity, while the upper margin of the body of the uterus is lost in

Our experience is obviously too limited to give an exhaustive exposition of the significance of the shadows seen. We have, however, tentatively reached certain conclusions which may be of value in the further study of this branch of roentgenographic work.

It appears that the normal pelvis is rather easily and regularly freed of all intestinal coils with the exception of that portion of the pelvic colon and the rectum which have no mesentery; and that this may be accomplished with a comparatively small amount

of gas. The shadow of the rectum is closely applied to the anterior surface of the sacrum, and as it is projected well above the shadows of the female generative system, it offers no confusion if the technique advocated is followed. It makes little or no difference whether it be full or empty. Even barium-containing feces serve only to fix the position or facilitate the orientation of the image.

If a perfect degree of elevation of the hips has been attained and the direction of the ray is in the long axis of the pelvis, both the anterior and posterior pelvic pouches are empty of everything but gas. In the presence of pathology, either the one or the other may be filled with inflammatory exudate or ad-

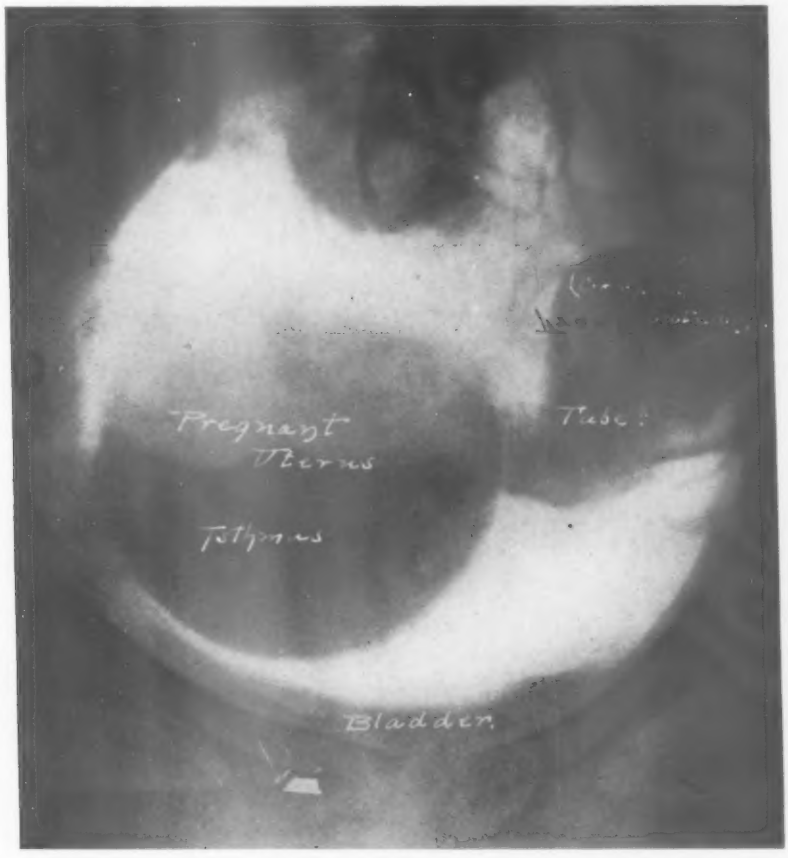

FIG. 2. PREGNANCY AT SIX WEEKS. Mass on the left, possibly the ovary, with corpus luteum vera.

Whether this rule of the mobility of the pelvic intestinal coils is so invariable as to justify the conclusion that the presence of such shadows is an evidence of pathological adhesions, remains in doubt and obviously will always remain dependent upon the care exercised in the details of the technique and, in particular, upon the quantity of the gas injected. With the exception of a few cases in which the inflation obviously was insufficient, that conclusion seems to be justified by our experiences.

hesions, or incarcerated bowels and omentum, with consecutive displacement of the uterus and the broad ligaments which form the transverse partitions of this portion of the pelvis. Such displacement with obliteration of either of the pouches is one of the most striking features of inflammatory disease of the pelvis.

When entirely empty, the bladder shadow is scarcely recognized on the posterior sur-

face of the pubic bone. When distended, however, it may be seen as a rounded shadow of no very great saliency exactly where one would expect to find it, and its recognition is never a matter of great doubt.

The fundus of the uterus in a properly placed patient is separated from the bladder shadow by the space of the anterior or utero-vesical pouch which normally contains gas.

ever, that the same result may be accomplished by a slightly greater elevation of the hips and a little more care in directing the ray.

On either side of the uterine shadows are seen the narrow linear shadows of the broad ligaments clearly spreading out at either end, centrally embracing the uterine shadow and peripherally fusing with the pelvic wall.

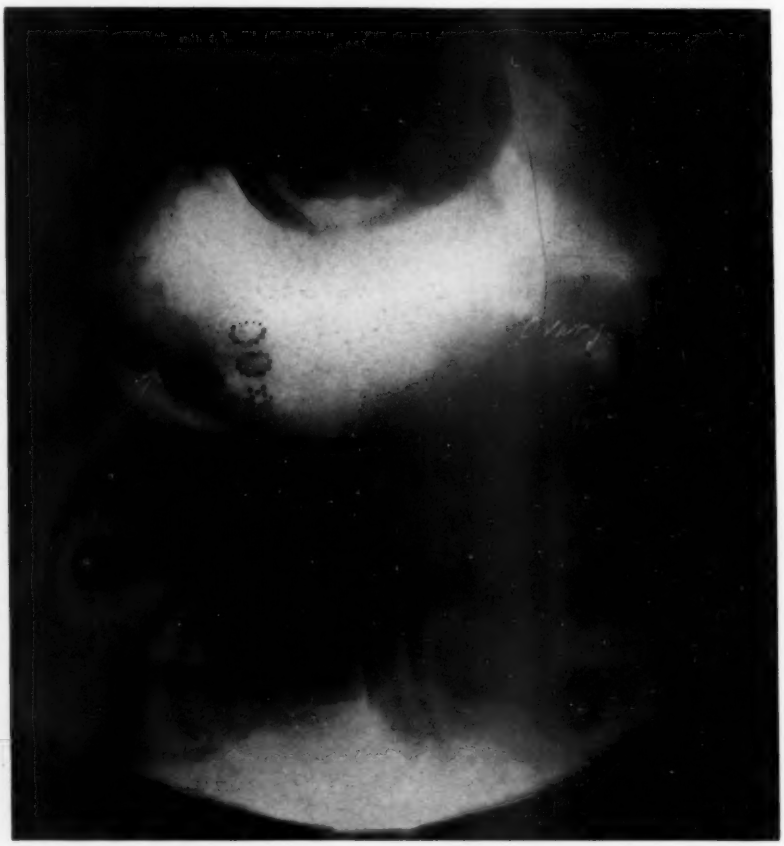

Fig. 3. Unilateral Disease of the Tube. At Operation Contained Pus.

In the presence of a marked relaxation of the pelvic floor, or where the position is not satisfactory, it may be found to lie on the posterior surface of the bladder and may be exceedingly difficult to recognize. This is particularly true in cases of senile atrophy. The introduction of a helix of wire into the vagina with the resulting dilatation of this cavity seems to help to throw this shadow backwards, more nearly into the axis of the pelvis. Our experience appears to show, how-

Where the uterus is displaced or distorted, these broad ligament shadows serve to direct one to the position of this organ. It appears that they are best seen at a level somewhat above that of the cervix, but well below the equator of the fundus.

We have never, to our knowledge, recognized the round ligaments and greatly question whether they would ever appear on the plate. We have once or twice imagined we could see them, but operation proved that

they lay in quite a different position. Careful examination of the opened pelvis gives us no reason to suppose that these exceedingly tenuous structures with their thin enveloping layers of peritoneum could reasonably be expected to show in the relatively large mass of tissues which the ordinary female pelvis presents.

The normal tubes are not seen as a separate or recognizable shadow. They apparently are component parts of the broad ligament shadows. When distended or inflamed, however, they become conspicuous as tortuous shadows on the posterior surface of the broad ligament shadows, possibly obliterating them by overriding, or as pear-shaped shadows in the postero-lateral portions of the pelvis. In chronic cases the picture may be much confused by the overlying (adherent?) intestinal coils. The distortion produced may make it difficult to recognize the shadow of the uterus and almost invariably the posterior cul-de-sac is much contracted and encroached upon by what appears to be inflammatory tissue and cicatrix.

The normal ovaries apparently are not seen. They probably lie on the postero-lateral aspect of the uterus slightly below the equator so that they form an integral part of the uterine shadow. Their position is exceedingly difficult to verify from the fact that the operation is invariably undertaken in the Trendelenburg position, while the roentgenogram is made in precisely the reverse, namely, the knee-chest position, and the effect of gravity would be to carry the ovaries upward rather than downward and backward. A curious observation is that the ovarian shadows are very conspicuous and easily recognized in cases of retroversion and "prolapse of the appendages," evidently being carried backward by the pathological shortening of the utero-ovarian ligaments. It is also worthy of note that a refractory retroverted uterus which cannot be replaced by ordinary manipulation appears to effect a

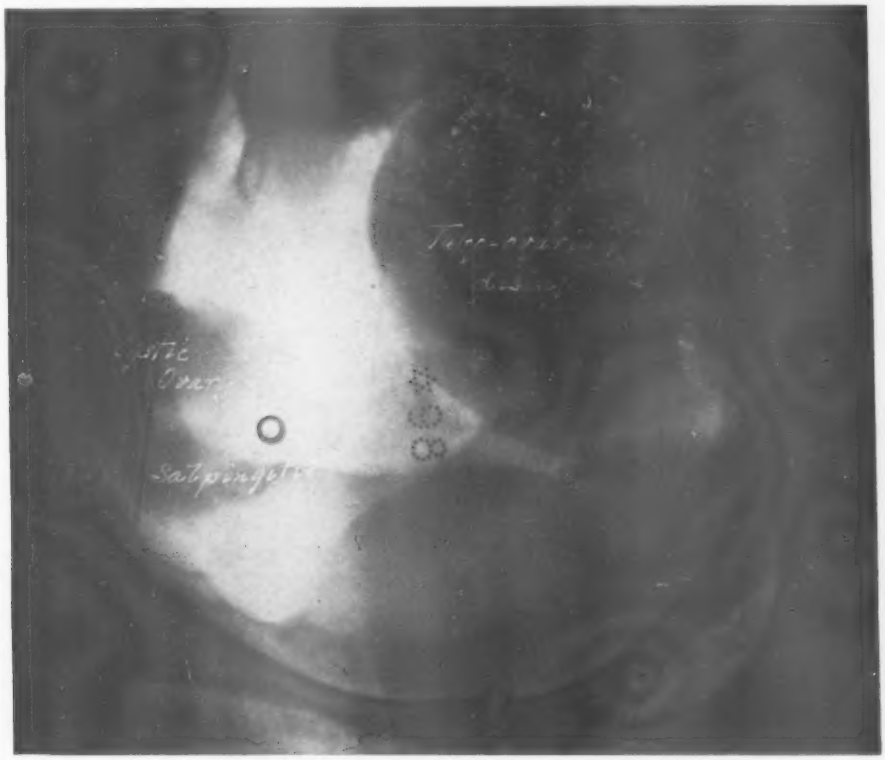

FIG. 4. BILATERAL TUBAL AND OVARIAN DISEASE.

spontaneous reduction and is represented by an enlarged fundus almost in the axis of the pelvis and flanked on either side and posteriorly by the conspicuous ovaries closely applied to its postero-lateral aspect.

Ovaries containing small cysts have been found and recognized as ovaries although the cystic element was not recognized. Larger ovarian cysts produce a variable picture that will leave one rarely in doubt. Considerable distortion may result, as in the specific case of a young girl with a pendulous cystic ovary which hung apparently almost in the exact axis of the uterus so that the differentiation of its shadow was impossible in the imperfect state of our knowledge at that time. The unusual mobility of this cystic ovary was clearly demonstrated at operation.

The cervix and the vagina, as well as all structures in the pelvic floor which lie below the level of the peritoneal pouches behind the broad ligament, are entirely undifferentiated, and it is entirely probable that considerable infiltration of the soft tissues in this neighborhood will leave no recognizable evidence. The insertion of a helix into the vagina serves to fix the position of this cavity and the direction of its axis; but pathology in this neighborhood, such as carcinoma of the cervix, may be expected to escape detection entirely except in so far as it encroaches upon the structures above the deepest portions of the cul-de-sac.

Enlargements and tumors of the pelvic organs cast conspicuous shadows and often rise into the abdomen. We are not yet ready to formulate any comprehensive set of rules for their differentiation, because of the paucity of our data. We tentatively offer the observation that the pregnant uterus casts a shadow less dense than myomata. One gets the impression of a high degree of elasticity, and the enlargement of the isthmus, or supracervical portion, of the uterus as seen in cross section, as well as the broadening of the broad ligaments, is more conspicuous in pregnancy than with tumors. Incidentally the shadow of the fundus of the uterus is not differentiated once it is out of the true pelvis, although its anterior surface at the plane of its inflection can sometimes be seen immediately behind the pubic bone. In fibroid of the uterus, on the other hand, the cross section of the isthmus is not enlarged, the mass has considerably greater density, and does

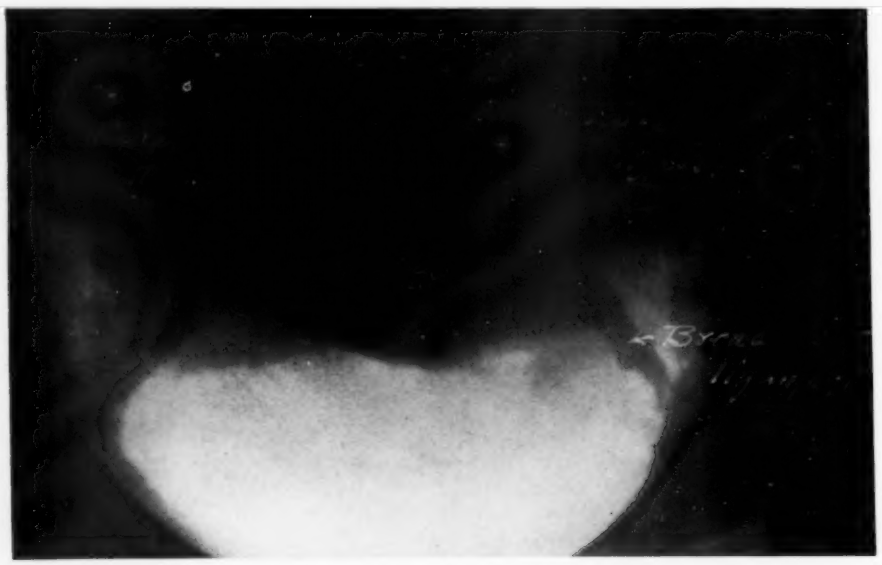

FIG. 5. CHRONIC PELVIC INFLAMMATION. Note the obliteration by adhesions of the posterior cul-de-sac and the distortion of the broad ligaments.

not appear to be flattened out as in the case of the pregnant uterus.

It would be an obvious error to attach any great weight or authority to the above hasty generalizations on so few observed cases. We have found that a diagnosis is anything but easy, and continue to meet with a discouraging number of disappointments. The findings, however, are so striking and the stereoscopic picture so intriguing that we cannot refuse to entertain the hope that reliable criteria of interpretation will be developed by a continuation of these studies. Both Dr. Peterson and myself are planning later communications on the results of this work as soon as reliable conclusions seem justified.

Even though the method can be developed to the point where a reliable judgment is possible on the part of the roentgenologist, it is not at all certain that his opinion will be of material diagnostic assistance to the gynecologist, since he, the gynecologist, is already fairly competent to reach a satisfactory conclusion by bimanual palpation. However, several instances in which interesting, if not essential, information was obtained, seem to warrant the expectation that the method will find a legitimate application in selected cases and furnish a common interest with still another specialized branch of modern surgery with which we, as roentgenologists, have heretofore found few points of contact.

[NOTE. The discussion of this and other papers relating to Artificial Pneumoperitoneum presented at the Twenty-first Annual Meeting will follow the publication of the entire series.]

THE TREATMENT OF CARCINOMA OF THE BREAST BY IMBEDDING RADIUM SUPPLEMENTED BY X-RAY*

By RUSSELL H. BOGGS, M.D.

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PITTSBURGH, PENNSYLVANIA

IN all the progress made in recent years in radiotherapy, nothing has been evolved of such significant import in the treatment of carcinoma of the breast, as the advanced method of imbedding radium, with its manifold and varied advantages and possibilities in deep therapy. By imbedding radium throughout the entire breast, in the axilla, into the glands leading from the breast to the axilla and into the glands below the clavicle, it is now possible to make radiation for carcinoma of the breast as thorough as a radical dissection without opening the lymph channels. Supplementing Coolidge *x*-ray treatment to the twenty or more lymphatic chains draining the breast, using 10 mm. of aluminum and cross-firing as much as possible, there is completed the most advanced and most effective treatment, which is in marked contrast to the treatment given fifteen or twenty years ago with a comparatively low penetrating gas tube, using no filtration or meters for giving exact dosage, and thus administering only superficial radiation when deep treatment was necessary.

In the early days of radiotherapy a deep lethal dose could not be given without producing superficial ulceration or necrosis. By imbedding radium a lethal dose can be given without any effect on the skin. Besides the subcutaneous tissue will tolerate from three to five times as much radiation as the skin. The result of radium in malignancy depends upon whether a lethal dose is given. Formerly it was concluded, because our best radiograms were taken with comparatively low tubes, that this form of radiant energy was the most suitable for deep therapy. Almost every one overlooked the loss of energy by absorption in the tissues and by divergence of the rays, and practically nothing was known about the lethal dose of different types of malignant cells. Most radiologists compared everything with the amount of radiant energy necessary to destroy rodent ulcer; and when the squamous cell epithelioma, axillary nodes and a cancerous mass in the breast did not disappear under *x*-ray, the radiation was considered useless. The real fact was that a lethal dose had not been given.

Radiation for the treatment of carcinoma of the breast has been so changed by imbedding radium that where only superficial skin effects were formerly produced, now cancerous tissue deeper than that which can be removed by the knife can be destroyed without opening the lymphatic chains. Before imbedding radium I always give surface applications in the axilla and over the glands below the clavicle, and I give a complete course of heavy filtered *x*-ray treatment to the breast and all the glands draining it. This checks cell proliferation and lessens the danger of metastases when the breast and adjacent lymphatics are speared and radium inserted. It is generally agreed that it requires from two to four weeks to check cell proliferation. It has been shown that the lymphatics begin to undergo a fibrosis at the end of the fourth week and that the caliber of the lymphatic vessels are smaller than before treatment was given. It seems just as advisable to give surface treatment before imbedding radium as before operation. Some few surgeons are now advising ante-operative treatment, and if they would include imbedding radium and remove less tissue, thereby leaving the sclerosed lymphatic tissue as a barrier against cancer cells, I feel

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

sure that the end results would be better, at least in borderline cases; that is, there would be fewer recurrences, and if a recurrence did take place it would be considerably later than when the operation precedes radiation.

Imbedding radium in the treatment of carcinoma of the breast is a step in advance, but the number of cases treated by this method are not sufficient and its use is of too short duration to speak about anything but temporary results. Even in some of the advanced cases the disease in the breast and the glands appears to have retrogressed, clinically. Of course in some cases there is still thickening due to the fibrosis from the radiation. Not enough cases have been operated upon to give definite histological changes. In the inoperable cases we were inclined to leave well enough alone, and in the early cases each one has refused operation. My advice has been, even in the advanced cases, where the disease has clinically receded, to have the breast removed without opening the axilla; but to my extreme disappointment, in almost every advanced case that I turned over to the surgeon he opened the axilla, and when the patient returned, almost without exception she had a swollen arm and was in much worse condition than before operation. I feel sure, however, that if we could have the surgeon remove only the breast, thereby taking away the unhealthy mammary gland, the patient would be greatly benefited. I am speaking of the advanced or inoperable cases which have had thorough radiation, and not the early cases which we are advising to have anteoperative radiation. Imbedding radium as described takes the place of operation in advanced cases, and as before stated, the removal of the breast is all that is advised.

It is imperative that every therapeutist should make a comprehensive study of the lymphatics draining the breast before he attempts to treat mammary carcinoma. The lymphatic supply to the breast is greater than to almost any other organ of the body. A study of the lymphatic and bone metastases will show that although the case is operated on early, the raying of the line of incision, axilla and supraclavicular region is very incomplete.

Deaver's classification in regard to end results are probably as near correct as that of any other author and should be studied by the surgeon and radiotherapeutist. He says: "It has been stated that 80 per cent of patients in whom the disease is confined to the breast, as proved by both microscopic and macroscopic examination of the tissues adjacent to this organ, are permanently cured of their disease by the radical operation. Therefore, a patient presenting a small movable mass localized in the breast can be assured that four out of five cases of a similar nature are cured by operation. When axillary lymph nodes are palpably enlarged as the result of metastases, the chances of operative cure are at once diminished to one in five."

This deduction is practically the same as that of Halstead, who says that, notwithstanding the present day extensive operation, death from metastases occurred in 23.4 per cent, even in cases with a microscopic negative axilla. Deaver questions whether as much palliation is received from operative as from non-operative methods, and expresses his general dissatisfaction with operation of a palliative nature in the treatment of carcinoma of the breast, since in certain cases the disease has been excited to greater activity by an incomplete operation, and the life of the patient considerably shortened.

In this connection he mentions the unreserved statement of Bloodgood, "that incomplete operation hastens death."

The above quotation which is taken from Deaver's carefully prepared volume, "The Breast, its Anomalies, its Diseases and their Treatment," should receive more attention from the medical profession.

The prognosis and treatment of mammary carcinoma can be estimated only after consideration of many factors. Hanley considers operation contra-indicated when there is extensive ulceration and when the tumor is adherent to the chest wall; when axillary

nodes are flexed; when there is supraclavicular involvement and when there is indication of distant metastases. When the axillary glands are palpable there are very few cures by surgery alone without radiation, even when the axillary nodes are not palpable; and when the glands are found to contain cancer cells microscopically only about 20 per cent of the cases are cured at the end of five years. Greenough claims that when the axillary nodes are palpable, 12 per cent were cured by operation, and Finsterer stated 4.3 per cent. Ewing believes the latter represents the average success by surgery, which means that a woman who has a well established cancer of the breast, with palpable axillary nodes, has one chance in twenty-five of being cured by operation. Therefore, in cases of this class it is not too much to advise imbedding radium and giving a thorough course of radiation before the removal of the breast.

The clinical and pathological studies of cancer of the breast have shown that both surgery and radiotherapy meet with many difficulties and uncertainties. The anatomical types are so many, the variations of the clinical course are so wide, the paths of dissemination so diverse and the difficulty of determining the actual condition so complex, that giving a lethal dosage is difficult. Since Deaver and Bloodgood both claim that an incomplete operation hastens death, there is good reason for advocating the imbedding of radium into the breast and into the adjacent lymphatics wherever possible. A study of autopsies shows that almost any organ of the body may metastasize from cancer of the breast, and however closely confined to the superficial tissues the growth seems to be, no one can tell where the cancer-growing edge may extend; although unappreciable by ordinary methods of examination, it is just as definite as ringworm. This shows us that even in the early cases no lymphatic chain should be omitted when raying the lymphatics with a Coolidge *x*-ray tube, and as much cross-firing should be used as possible. In an article which I read before this society in 1917, I described the glandular distribution of the breast and the method of raying with a Coolidge *x*-ray tube. Since then I have been using 10 mm. of aluminum, giving from fifteen to twenty minutes' exposure. At that time I made the statement that "we are all looking for some means by which the skin will tolerate larger doses." This has to a certain degree been accomplished by imbedding radium and using heavier filtered *x*-rays.

After cancer cells have reached the axillary nodes, the disease soon becomes generalized, and tissue in almost any part of the body may become involved. If we had an *x*-ray microscope and it were possible to give a lethal dose to all cancer cells, the end result would be different. When it is impossible to give a lethal dose, palliation and prolongation of life is obtained in nearly all cases. Less than a lethal dose will usually stop cell proliferation, produce a fibrosis of the lymphatics and obstruct or obliterate the lymphatic vessels, thereby checking cancer dissemination. In fact, radiation changes the character of the disease, transforming it into more of a scirrhus form, by decreasing glandular cells and increasing the fibrous stroma. This mechanical choking clinically seems to influence the constitutional resistance of a patient. The same difficulty is not encountered in giving a lethal dose when radium is imbedded in cancerous tissue as when deep seated metastases are treated either by surface applications of radium or *x*-ray.

In calculating the filtration and the number of ports of entry or the amount of cross-firing necessary to give a lethal dose to metastatic lymphatic glands, it is necessary not only to know the anatomical situation, but we must know the depth and density of the overlying structures. It makes quite a difference whether the glands are situated one-half inch or four inches from the surface. The erythema dose in carcinoma of the breast is very seldom the lethal dose. The lethal dose is from three to six times the amount of the erythema dose. Therefore, if a surface erythema dose is given and the

disease is four inches below the surface of the skin, the loss of radiant energy by divergence of the rays and absorption of the tissues with an *x*-ray tube placed eight inches from the surface with the equation used, is about one-ninth; or in other words, only about one-ninth of the surface radiation reaches four inches below the surface of the skin. Then if the lethal dose is from three to six times the erythema dose, it can be readily seen that when only one port of entry is used the treatment would be useless. Formerly, too many were satisfied with the removal of the visible part of the disease. The degree of malignancy is no guide to the amount of radiation determining its lethal dose. On account of rodent ulcer growing slowly and responding to small amounts of radiation, these circumstances led many to believe that a lethal dose was determined by the degree of malignancy of a tumor. Medullary carcinoma may respond more readily to radiation than the scirrhus type, but it grows more rapidly and invades the glands early, so if a cure or even an inhibitory effect of the disease of this type takes place, both the local tumor and metastases must be given sufficient radiation. If results are going to be produced in the medullary type, the cancer cells must show effect within three or four weeks, and fibrous tissue must be forming at the end of this time. In the scirrhus type, the fibroid formation has already taken place by nature's process.

When we speak of the lethal dose of radiation, we refer to direct action on malignant tissue; but there is an indirect effect of radiation on malignant cells by the formation of fibrosis which starts to form three or four weeks later. Both are important, and a lethal dose should be given whenever possible, but less than a lethal dose sickens the malignant tissue, as Mayo expresses it, and starts the formation of fibrous tissue which is a barrier against the disease. In locations where radium can be buried a lethal dose can nearly always be given, but in the treatment of deep metastatic glands we may be compelled to depend upon both the direct and indirect effect of radiation on malignant cells. Therefore, when carcinoma of the breast is so far advanced that a cure cannot be expected, the patient should have all the palliation possible from both the direct and indirect effects of radium and *x*-ray.

In a tumor that does not respond readily to radiation there is more necrosis and less absorption when a lethal dose is given. In two cases in which the mass in the breast was hard and of long duration, the growth was walled off, and when the breast was speared, broken-down non-offensive material came out through the trocar. This was due to heavy surface applications of radium. In each of these cases a clinical cure was obtained after imbedding radium, and the normal tissue was not injured in either case.

The ability to classify cases requires clinical experience and forms an important part of the training of the radiologist. The question of large dosage altering normal tissue after the reaction has disappeared is an important factor, and this alteration of tissues will not permit the normal tissue to bear so well a second, third or fourth exposure. The normal tissues are usually injured by a frequent repetition of the radiation, while the cancerous tissue, if any remains, may not retrogress in a proportional degree. In fact, the cancer cell and normal tissue may react in about the same degree, or there may be a reversal of the primary susceptibility. This shows the advantage of imbedding radium wherever possible after a maximum surface dosage has been given.

The method I have adopted is to give a thorough course of Coolidge *x*-ray treatment to all the glands draining the breast, using the following equation: 10 mm. aluminum, 8 inch tube distance, five milliamperes of current, nine inch spark-gap and from fifteen to twenty minutes' exposure. A constant voltage is difficult to obtain. The pastille erythema dose is very unreliable and is not as accurate as the milliampere dose, using the different types of transformers with a fluctuating voltage. Calculations based upon false assumptions have been very misleading, and

in giving a lethal dose exact standards must be employed. In many of the cases the breast and axilla receive a maximum dose from radium packs before imbedding radium.

Two or four weeks after surface applications I have been imbedding 10 mg. radium needles (vanadium steel needles, thickness of wall .35), placing them 1 cm. apart, and giving from five to eight hours' exposure. In some cases this produced a slight inflammatory reaction, but in no case has necrosis taken place. I may say that I started over three years ago—most reluctantly—to imbed radium in more superficial lesions; I can now indorse this technique as presenting many points of advantage over surface application in the treatment of many forms of malignant lesions, but it will not take the place of the Coolidge *x*-ray tube in the treatment of distant and deep metastases.

[NOTE. The discussion of this and other papers relating to Therapy presented at the Twenty-first Annual Meeting will follow the publication of the entire series.]

DISLOCATION OF THE CARPAL SCAPHOID

BY T. S. BONNEY, D.D.S

ABERDEEN, SOUTH DAKOTA

THERE is very little to be found in the literature relative to dislocations of the carpal bones except that the condition is very rare; and the following case seems worthy of report for that reason. I was privileged to make the *x*-ray plates of this case through the courtesy of Dr. C. E. McCauley of this city.

Mr. L. J., age twenty-one, suffered a fall from a horse on October 15th, striking on his right hand, and was seen by Dr. McCauley October 17th, at which time the *x*-ray examination of the wrist was made by myself.

The accompanying cuts show clearly the dislocation of the bone in question.

FIG. 1. SHOWING DISLOCATION OF THE RIGHT CARPAL SCAPHOID.

X-RAY TREATMENT OF TONSILS AND ADENOIDS

By W. D. WITHERBEE, M.D.

Radiotherapist, Presbyterian Hospital

NEW YORK CITY

FOLLOWING the suggestion of Dr. J. B. Murphy,[1] I treated the first case of hypertrophied tonsils in December, 1919, at the Rockefeller Institute for Medical Research.

This case, although carefully examined, revealed no changes in the surface size or outline of the tonsil, until the fifth week following treatment. The first evidence of the effect of *x*-ray was a smoothing out of the tonsillar mucous membrane, which very soon resulted in a glazed and somewhat pale surface.

This was followed by a rather rapid decrease in size, which in this case was most apparent in the left tonsil. At the end of eight weeks the left tonsil was seemingly reduced one half and the right one third.

About this time a dose similar to the first was given. Since then and up to the present time this patient has had no further trouble and the tonsils are apparently now both about one fourth the original size.

As soon as the effects on this case became conclusive Dr. S. L. Craig and I started a series of cases which numbered in all about sixty and ranged in age from sixteen months to fifty years.

In this series every patient was required to report for examination weekly. The history of each case was taken, a blood count made, the contents of the crypts plated and colonies of bacteria counted. A drawing of the throat and tonsils was made and notes were taken each time in regard to the progress of the case. Very few of these cases received more than one treatment, as we wished to determine the time necessary for the *x*-ray effects on the tonsil, and thus decide on the number of treatments required in a given case.

The amount of *x*-ray used in the experimental series of sixty cases varied from three to seven minutes time, depending on the age of the patient, with an 8 inch spark-gap, 5 milliamperes and 10 inches distance, filtered through 3 mm. of aluminum. This dose of filtered *x*-ray is less than the standard amount used for the past twenty years in the treatment of ringworm of the scalp in children, which fact overcomes the possible objection of any untoward effects on adjacent tissues from the standpoint both of amount, and of area of the head exposed.

In ringworm of the scalp five exposures are necessary in order to obtain uniform results of epilation. Only two exposures are necessary in each treatment of tonsils, and the maximum dose used is 1¾ skin units[3] of filtered ray, which corresponds to less than 1 skin unit used in temporary epilation of the scalp in children. It is generally conceded by most writers on this subject that the increased size of the tonsil depends directly upon the increase of the lymphatic tissue. The follicles appear larger than normal, are less sharply outlined, and usually the germinal centers are quite prominent and contain numerous mitotic figures. Occasionally the lymphoid cells appear to overflow into the interfollicular structures. According to Kellert[2] the hypertrophy of the follicles appears to cause distortion of the crypts, thus aiding in retention of the crypt contents.

The effect of *x*-ray on lymphoid tissue in the diseased tonsil is exemplified in the diagrammatic representation Figure 1. The destructive action of *x*-ray on the cells of the lymph follicles of both the lymphoid and fibroid tonsil are also well outlined.

The sections taken from an enlarged tonsil (Fig. 2) and the two made of tonsils enucleated eight weeks and four months after one massive dose of *x*-ray (Fig. 4) indicate the cause of the shrinkage of the tonsil and expulsion of crypt contents.

The selective action of *x*-rays on embry-

onic tissue or its effect on the cell in certain phases of mitosis are the usual methods of describing *x*-ray effects on diseased cells as compared with normal cells.

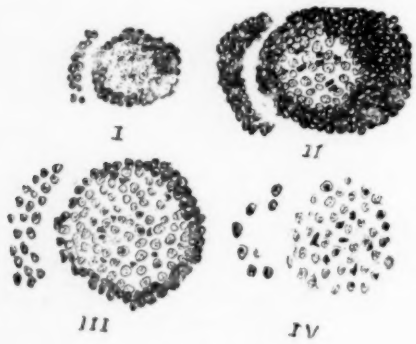

FIG. 1. I. Standard Lymph Follicle. II. Lymphoid Hypertrophy. III. Fibrous Hypertrophy. IV. Effects of *X*-Ray on Lymph Follicles.

The destructive action of *x*-rays on the cells of these enlarged lymph follicles might also be explained on the ground of their having been stimulated to excessive cell proliferation to such an extent that there remains less resistance to the *x*-ray than in the normal cell. Therefore this difference in resistance would account for the small dose of *x*-ray necessary to destroy these pathogenic lymph follicles without interfering in any way with the normal adjacent cells.

The bacteriological report embodied in the following table indicates the possibilities of the bacterial cryptic contents after one massive dose of *x*-ray. This case and a few others examined three months after *x*-ray treatment, showed negative cultures for pathogenic bacteria. The results in all cases were not as clean-cut as in this case. This might be explained by the fact that in passing the platinum loop into the crypt no method has as yet been devised whereby the surface of the tonsil can be rendered sterile in order

TABLE I

March 3, 1920

Right Tonsil,	24 hrs.,	50	Colonies of	Hemo.	Strep.
" "	48 "	100	"	"	"	"
		50	"	"	"	Staph.
Left Tonsil	24 "	50	"	"	"	Strep.
" "	48 "	50	"	"	"	"
		50	"	"	"	Staph.
Vault	24 "	50	"	"	"	Strep.
"	48 "	50	"	"	"	"
		150	"	"	"	Staph.

March 17, 1920—2nd Week After X-Rays

Right Tonsil,	24 hrs.,	No	Colonies of	Hemo.	Strep.
" "	24 "	"	"	"	"	Strep.
		No	"	"	"	Staph.
Left Tonsil	24 "	"	"	"	"	Strep.
" "	48 "	"	"	"	"	Strep.
		No	"	"	"	Staph.
Vault,	24 "	No	"	"	"	Strep.
"	48 "	"	"	"	"	Strep.
		No	"	"	"	Staph.

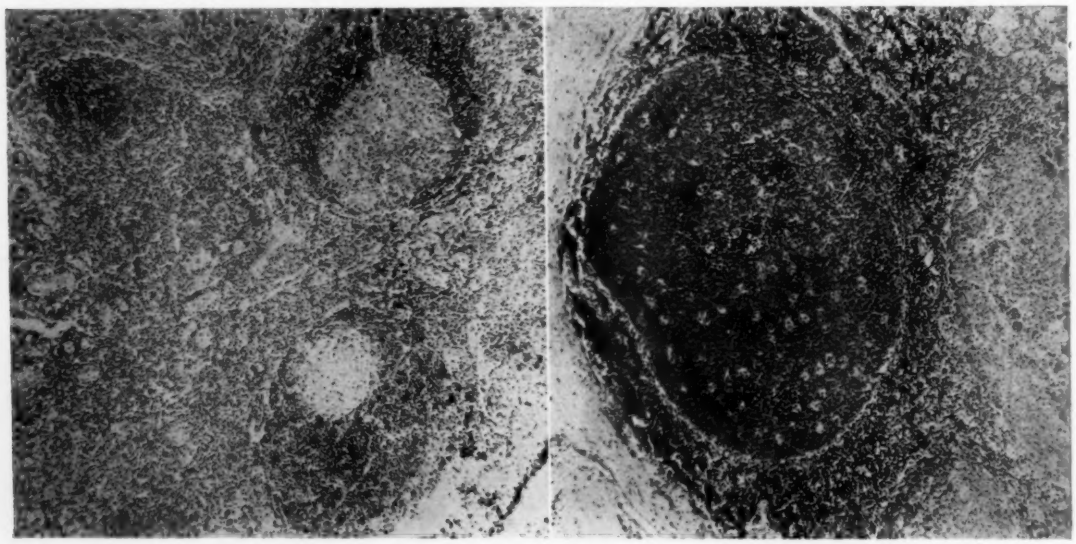

FIG. 2.

FIG. 3.

to avoid contamination from the mucous membrane. However, this can readily be accomplished with enucleated tonsils by dipping them for one minute in boiling water. Thirty-two out of thirty-six cases showed negative cultures for pathogenic bacteria four weeks after one massive dose of *x*-ray.

Figure 5 illustrates the diminution in size and characteristic changes in the surface of the tonsil at various periods of time after one massive dose of *x*-ray.

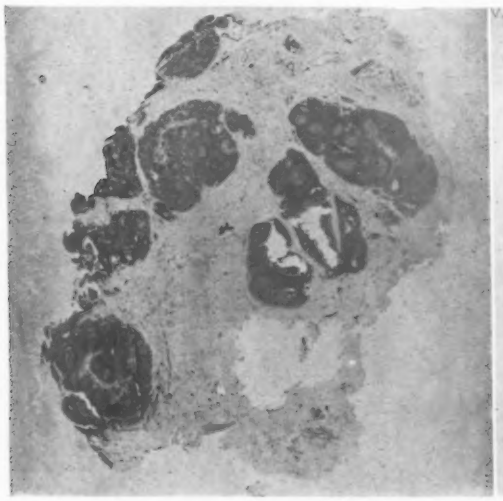

FIG. 4.

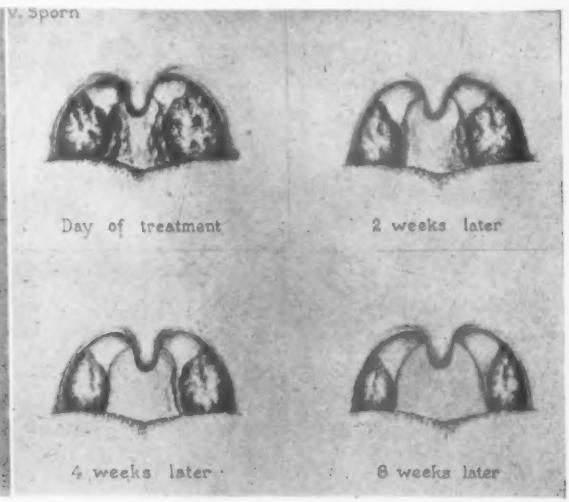

FIG. 5.

x-RAY TECHNIQUE

Figures 6 and 7, illustrating the position and immobilization of the younger patients give a much better idea of the practical application of the *x*-ray than the most accurate description. Figure 6 represents a board 4 feet long, 10 inches wide and 1 inch thick over all. The longest piece for the support of the body is 3 feet. The head piece is 1 foot by 10 inches and 1 inch thick with a bevelled opening 2½ inches in diameter. This opening prevents undue pressure and discomfort of the ear. The distance from the table level to the apex of the angle made by the union of the head piece and body support is 3½ inches. This angle and inclining head board not only give the position necessary for the direct exposure of the adenoids and left tonsil as shown in Figure 7 but also include the right tonsil and adenoids as the rays pass on through the opposite side of the head and neck.

This position can be assumed by the adult patient with the proper placing of pillows or cushions without the use of restraining straps and board so essential in the treatment of young children.

By maintaining the above position and placing the *x*-ray tube at the proper angle in both children and adults it is evident that each tonsil and the adenoids receive two doses of *x*-ray.

The opening in the lead foil, as in Figure 7, should be not less than 3 inches by 2½ inches for the average case. Figure 8 represents the area of exposure, and illustrates the area and position of the patient when a third exposure is considered necessary for cases with extensive growth of adenoids.

DOSAGE

In the experimental series of sixty cases treated at the Institute the following factors were used with 3 mm. of aluminum: 8 in. Sp. Gap. 5 M A 10 in. D and from 3 to 7 minutes time for each exposure depending on the age of the patient.

From the experience with these cases and

subsequent treatment of other cases, fractional dosage seems to promise better and more uniform results than the single massive dose used in the above series.

Fig. 6.

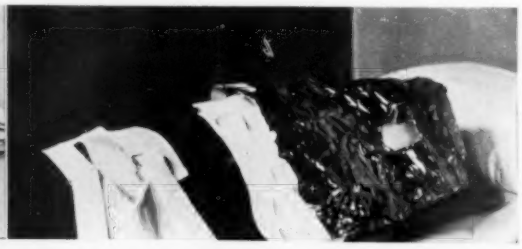

Fig. 7.

It therefore seems advisable to give each case at least four treatments as a minimum using the following factors every two weeks: 7 in. Sp. Gap. 5 M A 10 in. D and 3 min. 18 sec. time through 3 mm. of aluminum. These factors give 1 skin unit of filtered ray, which

Fig. 8.

corresponds to ½ skin unit unfiltered in effect on the skin. The same result may be obtained by producing 1 skin unit of filtered ray with a 6, 8 or 9 inch spark gap [5] 5 M A 10 in. D with 3 mm. of aluminum, or if necessary 1 mm. of aluminum could be used instead of 3 mm. to save time, especially with the small (2 K W) interrupterless machines where a 6 inch gap is maximum. The factors for 1 skin unit with 1 mm. of aluminum would be 6 in. Sp. Gap 5 M A 10 in. D and 2 min. 41 sec. time.[3]

The next best method would be two or three massive doses given with four to six weeks intervals.

DANGERS OF FAULTY TECHNIQUE

Before leaving the subject of dosage it is necessary to point out clearly that anyone contemplating carrying out this technique who does not thoroughly understand the part played by each of the four factors of dosage and who has not mastered his machine and tube so that all four factors are constantly maintained throughout the exposure will sooner or later produce an *x*-ray burn with its consequent permanent deformity and tendency to epitheliomatous degeneration. The only contra-indications to the immediate use of *x*-ray are: recent radiographs of the region to be exposed; recent *x*-ray treatment; the external application of any liniment, ointment or lotion other than vaseline, lanolin or cold cream. It does not seem advisable to give *x*-ray treatment during the active stage of an acute infection or immediately after applying nitrate of silver, iodine or any local irritant to the tonsil.

With the present day methods of measuring *x*-ray dosage and the constancy of the Coolidge tube and interrupterless machine, the dangers of the gas tube and the *x*-ray coil are practically eliminated. A Doctor's degree, years of experience in nose and throat, or even in radiography (*x*-ray plates), do not au-

Fig. 9.

tomatically fit any one for the practice of *x*-ray therapy.

On the other hand if the treatment is properly given as indicated, and the time lessened in both the massive and fractional methods of dosage in accordance with the age of the patient, there is not the slightest danger of injuring the skin or any of the adjacent structures, as exemplified in the results obtained for the past twenty years in the treatment of ringworm of the scalp. The immediate and after-effects of excision of the tonsil seem severe as compared with the *x*-ray treatment, which may produce dryness of the throat and a feeling of stiffness in the muscles of the neck. These symptoms are only apparent to the sensitive individual when the massive dose is used.

The extent of any after-effects of discomfort might be explained by citing the case of a young man to whom I gave three massive doses between 4 and 5 P. M., and that night he won the one-mile amateur championship in a local armory.

Recently Dr. Thomas R. French [4] has emphasized the presence of chronic infectious material in the crypts of the infratonsillar nodule as a possible source of systemic infections, and advocates their removal even though the operation is more extensive than that of tonsillectomy.

The infratonsillar nodules or tonsillar branches (Fig. 9) may overlap the under surface of the posterior lateral halves of the inferior lobes of the tonsil.

Those structures frequently referred to as infiltrates or recurrent tonsils are really nothing more than extended and expanded ends of these lymphoid bodies. The fossa, or space between the pillars left after removal of the tonsil, may be subsequently filled by the infratonsillar lymph nodule with its infected crypts. The infratonsillar nodes may progress in size as the tonsils themselves diminish or atrophy. Those nodes in some cases may be larger than their associated atrophied tonsil.

If the infratonsillar nodule with its pharyngeal and lingual branches (Fig. 9) exhibits all the characteristics both pathologically and histologically of the tonsil as indicated in the above article [4] with the results so far obtained with *x*-ray on tonsillar tissues, does it not seem reasonable to infer that not only will cases treated with *x*-ray have their tonsils reduced and crypts evacuated, but that the same process will prevail in the infratonsillar nodule, thus more thoroughly removing the focal infection than by tonsillectomy and that by this means better results will be obtained in combating those systemic infections dependent on this condition, namely, rheumatism endocarditis, chorea, septicemia, etc.?

The results of the study thus far open up possibilities of the *x*-ray in connection with tonsillar disease. One hopeful assistance is in the diagnostic value in determining the relationship between the focus and a given systemic infection, more especially those infections in which pain is a prominent symptom. If the bacteria are the causative factors of such pain, it would stand to reason that their evacuation would be followed by partial or complete relief. In such an event the most rational treatment could be definitely decided upon. Another hopeful assistance from the *x*-ray is to be considered in the possible evacuation of bacteria from the crypts of the tonsil in carriers, especially those of diphtheria and influenza. For it is hardly to be supposed that these bacteria would recur after such evacuation except by reinfection.

CONCLUSIONS

It would seem probable that *x*-ray treatment will be indicated in cases of diseased tonsils and infratonsillar lymph-nodes associated with chronic endocarditis pericarditis, hemophylia, or any co-existing conditions which contra-indicate operation or an anesthetic.

We know that after tonsillectomy in subjects above the sixth or eighth year, and especially in adults, there still remains a considerable and possibly a vast amount of diseased lymphoid tissue containing pathogenic bacteria, in which cases it would seem reas-

onable to believe that the *x*-ray will prove to be of value.

It must be understood that this paper is only suggestive, and that the permanency of the results time alone will determine. But the facts in so far as the experimental work has been carried out are presented.

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AN INEXPENSIVE RADIUM CAPSULE HOLDER

By GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

THERE is much risk in handling the capsules containing radium element, and in the process of screwing these capsules together or separating them there is unnecessary exposure of the fingers to danger. Any device that will help to keep the fingers at a distance will be useful and will lessen damaging effects. Several capsule holders have already been designed, but each one will fit only the capsule for which it has been made. I therefore searched in instrument stores and elsewhere, but finally went to the hardware store where I found a chuck which is 10½ cm. in length and which can be adjusted to take any of the capsules varying from 4 to 6.3 millimeters. The cost of this chuck is 85 cents, plus the labor of drilling the soft jaws. It is necessary to drill out the chuck in its central portion so that when it is wide open it will just grasp the largest sized capsule. This chuck is superior in my experience to the instruments made costing $12 to $15. It can be lengthened as much as desired by setting the handle into a wooden handle (Fig. 1). The remainder of the metal, if desired, may be covered with rubber. Having just spent twenty-five dollars for a pair of instruments that will not even grasp one size of capsule satisfactorily, I naturally "enthuse" over the above little instrument.

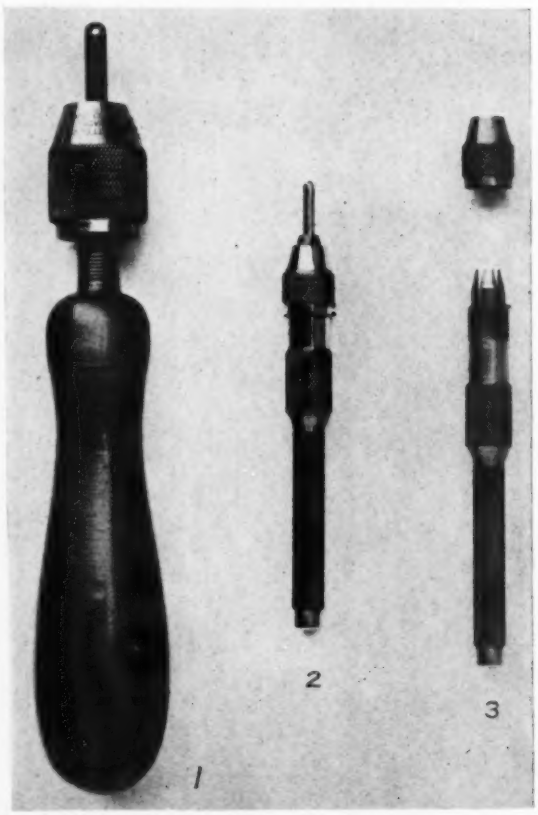

Fig. 1. Goodell Pratt Co. Second Size Drill Chuck. Will take any size capsule. Wood handle can be attached as shown in this figure.

Fig. 2. Starett Pin Vise Grasping one of the Radium Capsules.

Fig. 3. The Same Pin Vice with Cap Removed, showing the jaws which have been drilled out sufficiently to take varying sized capsules.

TWO UNUSUAL CHEST CASES*

By JOHN G. WILLIAMS, M.D.

BROOKLYN, NEW YORK

CASE 1. *History.*—First seen by Dr. A. A. Rutz, April 11, 1917. Female, age forty-eight. Married, and prior to her marriage a public school teacher.

Past History.—Fifteen years ago she had malaria, and ten years ago typhoid fever. She had never had diphtheria. There have never been any paralyses. Her menstrual history is negative, except that recently the periods have been prolonged.

She has always been of nervous temperament and suffered from gastro-intestinal disturbances. She was irritable and subject to emotional attacks of crying and laughing. These attacks in later life were followed by mental and physical prostration, necessitating rest in bed. At various times she has suffered from pain in the back of the neck and numbness and pain in various regions of the body. There was also insomnia and impairment of memory. She has always been constipated. Excessive secretion of saliva has been noted for years.

Fourteen years ago the patient saved a child from strangulation, a particle of food having entered the child's respiratory passage. This incident impressed itself so firmly on the patient's mind that, from this time on, she suffered from a constant fear of choking during her meals. At times this fear became so strong that it interfered with her deglutition. These disturbances of deglutition were always slight and transitory in character and consisted of sudden regurgitation of food from the esophagus, occasional coughing and choking, and the entrance of food into the nares. Her chief complaint at the time she consulted Dr. Rutz was belching of gas.

Physical examination at this time showed a few râles at the base of both lungs, a palpable right kidney and tenderness over the cecum and ascending colon. The knee-jerks were exaggerated.

On April 20th a test breakfast was given, following which a stomach tube was introduced and the contents of the stomach removed without difficulty.

On April 21st a test dinner was given to determine the gastric motility. A No. 23 French stomach tube was introduced without difficulty, but aspiration was impossible, and inflation showed that the tube was not in the stomach. The tube was removed and again inserted, with the same result, but it was noted that air passed through the tube with respiration. From this it was deduced that the tube was in the trachea and was removed. The patient was asked to swallow, but was unable to do so, as evidenced by failure of the larynx to move. Further examination showed that there was complete anesthesia of the pharynx and larynx. The gag reflex was absent and the insertion of the tube into the trachea caused no reflex cough or discomfort to the patient. The difficulty in deglutition was, at that time, considered temporary and unimportant, and was attributed to the patient's nervous condition, as she had looked forward to the examination with considerable apprehension.

On April 27th Dr. Rutz was called to the patient's home, as her condition had assumed a more serious phase. She was found sitting up in bed, suffering from considerable dyspnea and cyanosis, and imbued with the idea that her dyspnea was due to distention of her stomach. She was belching large quantities of air.

Examination of the abdomen showed no undue distention of the stomach. There was a large number of coarse mucous râles over both lungs. The physical signs in the chest were suggestive of pulmonary edema. Temperature, 101.6. Pulse, 130. Respiration, 36.

The patient was given water to swallow, but no deglutition sounds could be heard at the ensiform. Following this, the dyspnea

*Thesis presented with application for membership in THE AMERICAN ROENTGEN RAY SOCIETY, 1920.

and other chest signs increased. The cause, nature and seriousness of the patient's condition were recognized. The disturbance of deglutition previously observed had persisted so that her food was entering the trachea, and thereby interfering with respiration and subjecting the patient to the danger of pulmonary infection. Dr. Rutz now sent the patient to St. Mary's Hospital for treatment and observation. Rectal feeding was resorted to at first and later it was found possible, by

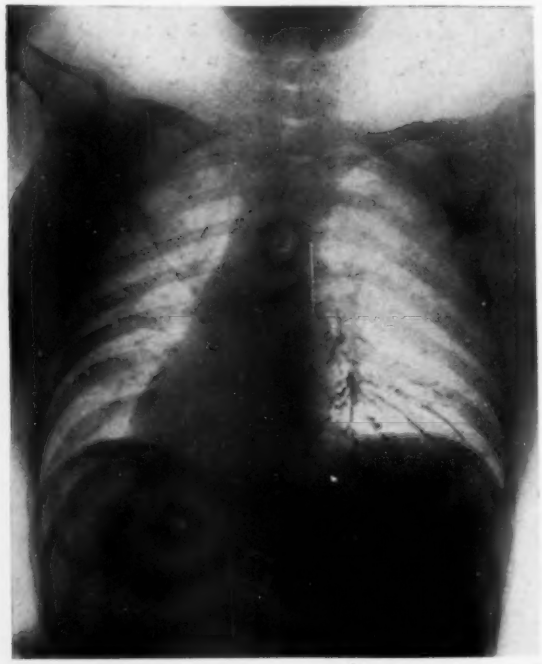

FIG. 1. CASE 1. Bismuth in Both Lungs and also in Larynx.

the use of a stiffer tube, to pass the same into the stomach, and the patient was fed in this way. Excessive secretion of saliva was a constant symptom at this time, but was controlled by belladonna. Her pulmonary symptoms rapidly cleared up and later her respiratory passages showed a marked tolerance to foreign material of various kinds. Various colored solutions were given and later coughed up. At one time six ounces of custard were apparently retained in the respiratory passages for twenty minutes and then gradually brought up by coughing.

On May 10th the writer examined the patient at the hospital. Two ounces of bismuth mixture were given the patient to swallow, and on the screen it was seen that most of this entered the trachea and thence on into the bronchi of both lungs. It apparently caused the patient no distress, and she did not cough as a result of it. Stereoscopic plates were then made, and it will be seen from these that the bismith mixture entered the lower lobes of both lungs extending well out into the smaller bronchi. Some few hours later, the patient coughed up much of the bismuth, and two days later the stereoscopic plates showed no trace of it in the respiratory tract.

For three weeks during her stay in the hospital complete aphagia was present. At the end of this time the patient began to swallow normally with occasional remissions, so that at times she had to be fed by tube. She was allowed to return home after four weeks' stay in the hospital, and a member of her family was instructed how to pass the tube and tube-feeding was continued for some time after leaving the hospital. The aphagia suddenly ended when one morning, at breakfast, she had an uncontrollable desire to drink some tea. She drank three cupfuls in succession, and from this time on had no difficulty in swallowing. When last seen, December 1, 1917, she was swallowing in a perfectly normal manner. Sensation had returned to the pharynx and larynx and none of her former symptoms were present.

The diagnosis in this case, made by Dr. Rutz before referring the case to the writer, is hysterical aphagia. The loss of sensation in the pharynx and larynx eliminated the second stage of deglutition, and the larynx was not elevated and protected by the epiglottis, so that, through gravity, the material swallowed dropped directly into the larynx. The retention of foreign material for so long a time in the bronchi indicates that there was diminished sensation here also. Difficulty in deglutition is not uncommon in hysteria and is mentioned in all of the text books on nervous diseases.

On looking up the literature, however, I am unable to find any cases reported in which *x*-ray examination revealed the condition as shown here, except a case reported by Pancoast in THE AMERICAN JOURNAL OF ROENTGENOLOGY, March, 1918, which may be of the same type. He merely says, in regard to the case, that the girl was referred for supposed esophageal stricture, but the obstruction in the esophagus was neurotic in origin.

FIG. 2. CASE 2. Plate made before meal showing dilated stomach and esophagus in right mediastinum.

FIG. 3. CASE 3. Right lateral view showing stomach and esophagus with penetrating ulcer on lesser curvature of stomach just above incisura.

CASE II. Referred by Dr. E. P. Porter, for examination of the stomach and duodenum, January 30, 1920.

History.—Male, age fifty-eight; occupation, salesman.

Previous History.—Negative, except for ordinary diseases of childhood. For the past twenty years or more the patient has had more or less digestive disturbances. These consisted of some difficulty in swallowing, in that he had to eat or drink slowly because of some distress in the mediastinum whenever he tried to eat or drink rapidly. He complains of soreness in the right hypochondrium, most marked soon after eating; also some gnawing sensation in the chest, behind the heart. These are relieved by belching of gas after taking alkalies. Occasionally, during the past few years he has had to bring on vomiting by tickling the pharynx to get relief. Of late the symptoms have been more constant and recently, having had a bronchitis, he noticed a tendency to regurgitation when he coughed, especially when lying down. He has never noticed blood in the vomitus, which usually contained food taken several hours previously. His weight was constant up to one year ago, but in the past year he has lost about ten pounds. The bowels are constipated. No history of acute abdominal or chest symptoms and no history of injury to the thorax or abdomen.

On screen examination, there was observed an abnormal shadow in the right chest, extending from the right clavicle to the diaphragm. The margin of this was smooth, except for an indentation opposite

the right second interspace. The left margin of this shadow was fused with that of the heart and vessels of the mediastinum. On rotating the patient, it was observed that this abnormal shadow was in the posterior mediastinum. The barium meal was observed to enter the upper portion of this shadow region and was delayed here for two or three seconds and then continued on into the lower part of the shadow, none of it passing below the diaphragm. Meanwhile, a considerable portion of the meal connected in the upper sac.

Plates were now made in various positions, such as standing direct, oblique and lateral; prone direct, oblique and lateral. An attempt was made to examine the patient on an inclined plane with the head lower than the feet, but he could not retain the meal in this position. Plates were made six hours after the meal, twenty-four hours afterward and forty-eight hours afterward. Stereoscopic plates of the chest were also made on one of these later visits when the chest contained no barium. Stereoscopic plates were also made in most of the positions above enumerated with a barium meal in the chest.

The plates made without barium in the chest show that this abnormal shadow in the mediastinum is not very dense, as the bronchial tree on the right side may be seen through this shadow. Stereoscopically, it is seen to be tubular and apparently contains air in the lower two-thirds, there being less marked distention above. In the plates made directly with the patient prone, most of the barium is seen in the lower mediastinum, behind the heart shadow. There is some barium also in the upper sac. In this position, the lower shadow assumes the shape of the stomach. In the right lateral position, with the patient lying on his right side, the lower sac seems to be the stomach; and the pylorus and antrum are visible, as well as the greater and lesser curvatures. All of the plates made in this position show a projection from about the middle of the lesser curvature suggesting a penetrating ulcer or adhesion here. The lower sac shows several indentations on both

FIG. 4. CASE 2. Six hour plate. Only small amount of barium in intestine.

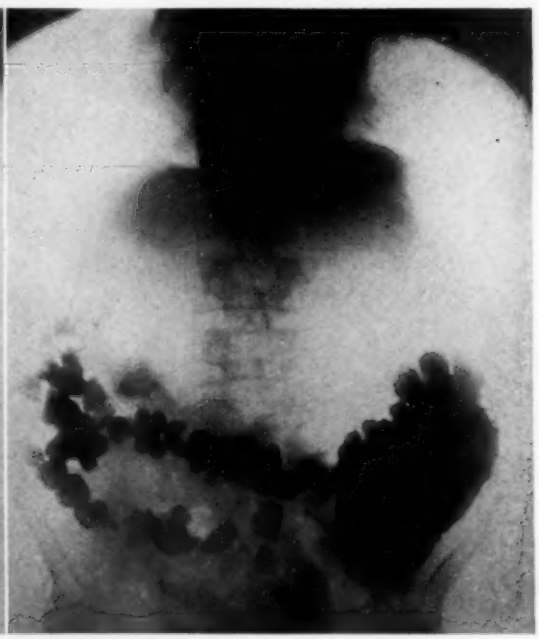

FIG. 5. CASE 2. Twenty-four hour plate. Stomach empty, most of meal being in colon.

sides, evidently peristaltic waves. The upper sac also shows sharp bilateral indentations suggestive of the haustral markings of the colon. In the plates made with the patient standing, little of the barium remains in the upper sac. The six-hour plate shows most of the meal still in the chest, a small stream being visible in the small intestine below the diaphragm. The twenty-four hour plate shows most of the barium distributed throughout the colon, with a small amount remaining in the terminal ileum. The patient's bowels moved spontaneously at thirty hours, so that later plates showed only traces of the meal in the colon.

From the above findings, I believe that the shadow in the right mediastinum is due to the presence here of the stomach and dilated esophagus above it. There is very little of the small intestine above the diaphragm. The dilatation and hypertrophy of the esophagus are due to constriction of the cardiac end of the stomach. The stomach empties some time between six and twenty-four hours (unable to get intermediate plates). The defective motility of the stomach is due to constriction of the small intestine, at the opening in the diaphragm, and spasm of the pylorus as a result of the lesion on the lesser curvature.

The small intestine is practically empty at the end of twenty-four hours. The condition now present has probably existed for many years. There is no history of trauma and no history of acute abdominal crisis. For this reason, it would seem that the stomach probably passed through one of the normal openings in the diaphragm, most probably the esophageal and that the esophagus was carried up into the chest with the stomach.

Hernia of the stomach and other abdominal viscera through the diaphragm was, until recent years, considered quite rare. However, since the advent of *x*-ray examination of the hollow viscera, the number of cases reported has markedly increased. Particularly is this true since the recent war. Necessarily, there were many wounds of the diaphragm, and as a result of these there have been many cases reported of hernia through these wounds, and some of these cases were not recognized until the patients had been through several hospitals. The cases difficult of diagnosis, even with *x*-ray examination, are those in which the opening in the diaphragm is small and a part only of the stomach or intestine is involved. Soresi has recently reported such cases.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

PUBLISHED BY PAUL B. HOEBER, NEW YORK CITY

Issued Monthly. Subscription, $6.00 per year. Advertising rates submitted on application. Editorial office, 480 Park Av., New York. Office of publication, 67-69 East 59th St., New York.

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ANNUAL MEETING EASTERN SECTION

The Second Annual Meeting of the Eastern Section of the American Roentgen Ray Society will be held in Atlantic City at Haddon Hall-Chalfonte, on Friday evening and Saturday, Jan. 28, 29, 1921. Make hotel reservations early, mentioning American Roentgen Ray Society.

Communications regarding the program should be addressed to Dr. David R. Bowen, 82 West LaCrosse Ave., Lansdowne, Pennsylvania.

In all other matters concerning this meeting address Dr. Joseph M. Steiner, 103 Park Ave., New York City.

ANNUAL MEETING CENTRAL SECTION

The Second Annual Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY will be held on February 21, 1921, at St. Louis, Missouri. Announcement of headquarters will be made later.

Communications regarding the program should be addressed to the president, Dr. James G. Van Zwaluwenburg, Ann Arbor, Michigan. The chairman of the local committee, Dr. Edwin C. Ernst, 412 Humbolt Building, St. Louis, may be addressed concerning matters of arrangements.

THE CALDWELL LECTURE

THE AMERICAN ROENTGEN RAY SOCIETY has sought to honor some of its former members, martyrs to their profession. Two thus far honored are Leonard and Caldwell. At the last annual session, a Leonard prize was voted, details of which will be found elsewhere in this number. Eugene W. Caldwell's work placed him in the foremost rank of American medical scientists, and it is highly fitting that each year the memory of our beloved co-worker shall be freshened by a lecture given in his name. It is planned to have an hour set apart on each annual program for a formal lecture on some topic relating to roentgenology or radiumtherapy, the speaker to be chosen by the president each year. For the first Caldwell lecture at Minneapolis, Minnesota, Thursday afternoon, September 16, 1920, we had the honor and the privilege of hearing Dr. Walter C. Alvarez, Assistant Professor of Research Medicine, George Williams Hooper Foundation for Medical Research, University of California Medical School, San Francisco, California, on "Peristalsis in Health and Disease," whose paper appears in this number. JAMES T. CASE.

COMMUNICATIONS

PARIS LETTER

DURING the course of the war a large number of French and American radiologists had occasion to meet and to work together in the various medical organizations at the front and in the interior. Thus were established those sympathetic and friendly personal relations which make it more desirable than ever that they keep in touch with each other and that they reciprocate in their labors and their researches. Constantly informed by his faithful and eminent friends of the remarkable development of radiology in the United States, and endeavoring to pass on to those about him all that he thus learns, the author of these lines has long hoped that his colleagues in the United States might come to take an equal interest in French radiology.

FIG. 1. DUC DE BROGLIE.

FIG. 2. DR. A. DAUVILLIER AT WORK IN THE LABORATORY.

He therefore accepted joyfully, in spite of very numerous duties, the proposition transmitted through Dr. Béclère, Master and Dean of French radiology, to write for the readers of THE AMERICAN JOURNAL OF ROENTGENOLOGY a monthly letter from Paris portraying as faithfully as possible our radiologic activities; and he takes this occasion to congratulate his colleagues, particularly Drs. Hickey and Imboden, on their initiative in creating this new department.

He will endeavor to present in these articles all that is new and interesting in France in the various domains of radiology and radium therapy, and at the same time he will seek to inform those in the United States who may have occasion to come to France as to the hospital services and the laboratories which they will find it most profitable to visit.

Modern research tends to show that all progress which may be made in the application of the *x*-rays to medical diagnosis and treatment is inseparable from physical research, and that all productive work thus necessitates the active and continued collaboration of the physicist, the constructor and the radiologist—that is, the constant union of theory and practice.

One of the first to perceive clearly this necessity was the eminent physicist M. Villard, of the Academy of Science, to whom we owe the discovery of the gamma rays of radium, the invention of the osmo-regulator, and the appearance in 1908 of the first ap-

paratus for the measurement of the *x*-rays by ionization. We owe to Dr. Coolidge, together with the most important advance in radiologic technique since Roentgen's discovery, certain facilities for experimentation which profit medicine and physics equally, and which give a new impetus to the collaboration of these two sciences.

A number of French radiologists, therefore, have thought the moment well chosen for the establishment of a laboratory for research in the field of *x*-rays, and to facilitate the study of all questions which may directly or indirectly interest either physicians or technicians.

The Duc de Broglie, well known for his spectroscopic studies of the *x*-rays, and who has at present for his personal use a well-equipped laboratory, has generously offered, to shelter the new organization, an entire building completely furnished and equipped with the most excellent and modern apparatus. Except for the very modest assistance of the writer, the Duc de Broglie oversees entirely the functioning and maintenance of the laboratory, and assumes the scientific direction of it.

Dr. M. A. Dauvillier, a young physician of great future, already known by his interesting work with the *x*-rays, is attached to the laboratory. Some of the readers of this letter will perhaps remember having seen him during the war in the *x*-ray department of the Descartes hospital at Tours, where we first realized the value of an intimate relation between a physical laboratory and a medico-surgical *x*-ray service. For, modest as it was, that laboratory where so often Colonel Shearer lavished upon us the precious counsel born of his long experience, was the scene of some research work which the Academy of Science viewed with interest, and the continuation of which it encouraged with an important prize.

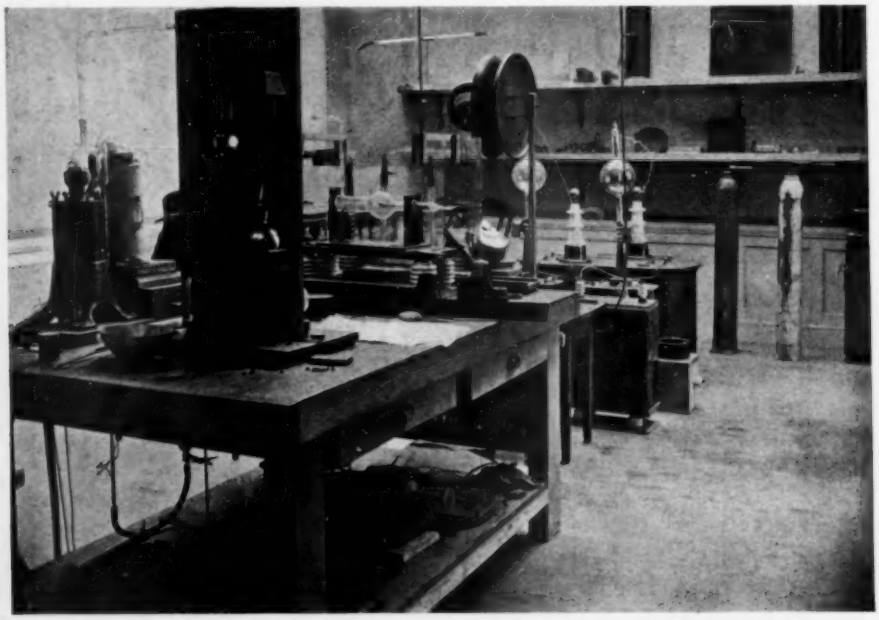

FIG. 3. VIEW OF RESEARCH ROOM IN THE LABORATORY, SHOWING IN THE BACKGROUND HIGH-TENSION TRANSFORMER WITH KENOTRONS AND CONDENSATORS FOR CONTINUOUS HIGH-TENSION WORK. A quartz tube and the Abraham-Villard voltmeter are visible in the center, whilst the vacuum pump shows in the foreground.

We may hope, therefore, that under the direction of the Duc de Broglie, and profiting by his large experience, the laboratory will not delay in giving proof of its utility.

To describe it briefly, it is housed in a building having a basement and two stories.

In the basement are a preliminary vacuum apparatus (a motor and a pump working in oil), and a converter for changing 110 V. D.C. into 250 V. single phase alternating current of 600 periods (60 cycles). This group has a capacity of 5 K.V. A.C. The ground floor includes an office, a dark room, and two laboratories. The smaller laboratory is at present reserved for the study of Lilienfeld apparatus. The larger one contains (a) a coil with mercury interrupter working on the 110 V. D.C., and (b) a Gallot-Gaiffe transformer working on the 120 V. single phase alternating current, and which can supply the incandescent cathode type tubes with a maximum of 170 K.V. controlled by an auto-transformer. Voltages are measured by an Abraham-Villard electro-static voltmeter. This laboratory has also facilities for pumping vacuum tubes, namely, a special quartz condensation pump, with a Gaede rotary pump for preliminary pumping, permitting the obtaining of very high vacuums with considerable speed; and a Pilon apparatus.

The spectroscopic apparatus in use includes a Bragg spectrometer and a Broglie spectrograph. These permit the simultaneous analysis of rays from two sources enclosed in lead boxes of about one cubic centimeter capacity, and having a wall thickness of 15 mm. Two other pieces of spectroscopic apparatus, including a monochromateur, and a spectrograph of special precision for the study of very short wave lengths, are under construction.

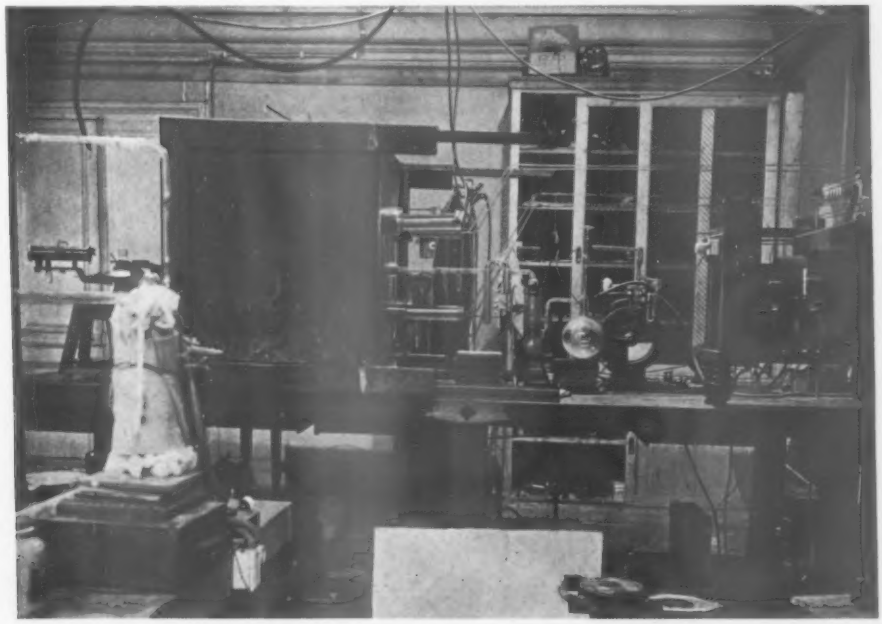

FIG. 4. ANOTHER PART OF RESEARCH ROOM, showing the quartz vacuum pump and Gaede pump on the right, the large lead box (weighing over a ton) in the center, and the spectrometers on the left.

The experimental tubes used are almost exclusively constructed of quartz.

The researches undertaken by the laboratory are not confined to purely theoretical physics. An important place is reserved for all questions of interest from the medical viewpoint, and particularly for radiotherapy, which is closely connected with the study of rays of very short wave length.

Finally, the laboratory, endowed with a very complete library, may be regarded (although not public) as a center where workers lacking information on certain points of physics of radiology may bring their problems, and continue their researches.

If the readers of this first letter reproach

us with having dealt exclusively with physics, we hope that Dr. Coolidge, who manifested his interest in the new creation when he visited it last August while it was under construction, and who considered it to be the only institution of its kind in the world, will deign to say a few words in our defense. He will agree with us perhaps that the future of radiology, and particularly of deep radiotherapy—a domain as vast as it is interesting—depends entirely upon the close collaboration of the physician and the physicist.

The description we have given will serve as an introduction to the letters which will follow, and if it has seemed wearisome to some of our American colleagues because we have not spoken of medical radiology, we hope they will pardon us, and we promise them that we will not stray into the domain of physics again for a long time.

DR. R. LEDOUX-LEBARD.

BOOK REVIEWS

THE STORY OF THE AMERICAN RED CROSS IN ITALY. By Charles M. Bakewell. Pages 225. Illust. Price, $2.00. Macmillan Co., 1920.

This most attractive volume is a faithful history of the accomplishment of the American Red Cross in Italy beginning with May, 1915, the date of Italy's entrance into the war, and continuing the narrative until up to the middle of 1919, when Red Cross war activities were practically closed in Italy. The book tells not only of the establishment of relief centers, work-houses, traveling canteens, "asili" for children and large hospitals, but also of the building of entire cities for the accommodation of refugees from the Piave and from Venice. It is highly fitting that the accomplishments of the American Red Cross should be thus chronicled. We hope there will be a wide distribution of this work.

JAMES T. CASE.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

LOVETT, ROBERT W., AND WOLBACH, S. B. Roentgenographic Appearance, Diagnosis, and Pathology of Some Obscure Cases of Bone Lesions. (*Surg., Gynec. and Obst.*, Vol. xxxi, No. 2, August, 1920.)

For the past five years the writers have been concerned in a conjoined study of certain obscure bone lesions, occurring in the orthopedic service of the Children's Hospital. In cases where the diagnosis of a bone lesion was in doubt, the pathologist has been present when operations were to be performed, and has taken his own specimen when the bone was opened, so that if possible an immediate diagnosis could be made by frozen section, and the operative wound treated accordingly. When the pathologist could not make a diagnosis in this way, the specimen was taken to the laboratory, studied, and reported on later. The cases presented are those in which there was, in the minds of the writers, doubt as to the correct diagnosis from the *x*-ray and other data available before operation. Each case is presented with a short clinical history, an *x*-ray and a pathological report. The writers are indebted to Percy Brown, radiologist of the Children's Hospital, for co-operation in the study, and to John J. Morton, of Boston, also a hospital associate, for much labor in the collection and arrangement of the data. Considering the behavior of bone in general, as studied by the *x*-ray, it seems to be a structure of very limited reaction to pathological conditions. Regarded from this point of view, there seem to be only three reactions possible in bone. These are: (1) atrophy or diminution in line content; (2) destruction of bone tissue, local or general; (3) a formative process, characterized by formation of new bone, or a condensation of existing bone around a focus of disease. The general point of view with regard to these processes has been that tuberculosis is largely destructive in character; that the tuberculosis is characterized by marked atrophy of the affected bone, with perhaps atrophy of contiguous bones in the same limb; and that it occurs in the region of the epiphysis. Osteomyelitis has been generally regarded as a process at first destructive in character, and then formative, the formative process generally becoming dominant. Syphilis has been considered as the most purely formative of the three processes, with some element of destruction, but much more formative than either of the others mentioned. When the writers attempted to study, from the point of view of pathological findings, *x*-rays taken of cases prior to operation, it became evident that this criterion could not be depended upon; that tuberculosis, which has ordinarily been spoken of as occurring in the articular ends of bones, might occur in the shaft, and that it might be almost a purely formative process, or that the formative process might exist with the destructive process, and ultimately become dominant; and that a local destructive process, indistinguishable from the so-called Brodie's abscess, might occur in a pure tuberculosis, so that a localized cavity in bone, well walled off, might occur in this disease. It appeared also that a wedge-shaped destruction in the articular end of the bone, with the base of the wedge toward the joint, might occur both in tuberculosis and osteomyelitis, and that under these circumstances the two were practically indistinguishable. The errors in diagnosis, in the experience of the writers, have more often consisted in mistaking tuberculosis for other things than in mistaking other things for tuberculosis. A curious punched out lesion of the skull was identified pathologically in two cases as being definitely tuberculosis. The other confusion which was most troublesome arose between osteomyelitis and spyhilis, two cases involving the lower end of the fibula being shown which were in *x*-ray appearances practically identical. Again, the stage of repair in osteomyelitis may be seen in the *x*-ray of two tibiae to be very similar in spyhilis and osteomyelitis. As it has appeared to the writers, the problem of differentiating the three conditions mentioned by means of the *x*-ray, is not encountered, as a rule, in the routine case in which a purely destructive lesion is most often tuberculosis. The lesion of rapid destruction, with marked formative activity, is generally osteomyelitis, and the purely formative process is most likely to be syphilis. The serious problem of differential diagnosis occurs most often in cases in which focal lesions are present, in which the phenomena of formative and destructive ac-

tivity have become so mixed that without the pathological examination, in many of them the diagnosis is impossible. The advantage of such a diagnosis made during the operation is evident to any surgeon, because it guides him in the treatment of the bone cavity, and is often the direct factor in deciding whether or not to close such a cavity. In addition to the three conditions of tuberculosis, osteomyelitis, and syphilis, certain other bone lesions are shown, which have a bearing on the question of diagnosis. A short summary of the case histories will be presented, the salient pathological facts discussed, and conclusions drawn as warranted.

DISCUSSION

The diagnosis of infectious lesions of the bones would be simple if each infectious agent always produced the same reaction. The pyogenic bacteria alone may be counted upon to conform to type; at first destruction of tissue followed by repair, which in the case of bone means necrosis with more or less local disappearance of lime salts, followed by new bone formation from adjacent healthy bone structures. It must be remembered in the reaction of bone to injury that new formation of tissue is always followed by ossification and therefore that granulation tissue from bone or periosteum becomes bone tissue. The above simple sequence in the pyogenic infections accounts for the definite criteria applicable in osteomyelitis. It is conceivable that a rapid healing of a small abscess in bone might result in very little granulation tissue production from adjacent tissue with very little production of new bone. Syphilis affects the bone in two ways, both effects of the proliferative reaction of the casual agent, and results either in the destruction of bone, or the new formation of bone. Both effects may occur in the same case. Destruction of bone follows the formation of local, rapidly-formed gummatous lesions, sometimes of endosteal and periosteal origin, sometimes perivascular and extending into bone. On the other hand, the degree of reaction to the spirocheta may be slight and result only in proliferation of cells of the periosteum and endosteum, the newly-formed tissue developing osteoblasts and eventually new deposit of bone is the result. In one case, therefore, there is choking of normal bone by the gummatous process with its necrosis; in the other case there is merely stimulation of bone-forming tissue. Tuberculosis presents more possibilities. In soft tissues it is known that the tubercle bacillus can duplicate the reaction of almost any type of pathogenic bacterium. Thus the various types of exudative response to injury may be the result of the tubercle bacillus alone; exudates essentially fibrinous or essentially puriform in character are frequently found upon serous membranes—meninges, peritoneum, pleura, and pericardium. In bone we usually think of tuberculosis as a proliferative process resulting in the new formation of tissue with consequent obstruction of the bone, and this is the commonest type of tuberculous bone lesion which gives rise to the formation of bone cavities without a peripheral reaction or condensation of bone.

In tuberculosis of bone, as in soft tissues, there may occur: (1) Exudate, fibrinous or puriform, (2) discrete proliferative lesions, the tubercle which may progress slowly or rapidly with much or little caseation, and (3) a diffuse proliferative reaction, following the exudative—essentially tuberculous granulation tissue, with much or little caseation. In the third instance, in the granulation tissue, there may be new bone formation just as in the repair of pyogenic processes, at a time when destruction or resorption of bone is going on.

The important lesson from the pathological study of this series of cases is the reminder that tuberculosis in bone may simulate any other infectious process in location and character of the lesion. Diagnosis from *x*-ray studies alone is therefore occasionally impossible and recourse must be had to other clinical evidence, and when possible to pathological examination.

CARMAN, R. D., Mayo Clinic. The Roentgen Diagnosis and Localization of Peptic Ulcer. (*Calif. State J. of Med.*, November, 1920, Vol. xviii, No. 11.)

Many roentgenologists refuse to make a diagnosis in the absence of direct signs, and claim that complexes made up of indirect signs are of no value. This view is far too radical, for if roentgen ray diagnoses were limited to cases in which direct signs only are noted, many lesions of the alimentary canal would pass undiscovered. Often more remote phenomena must be considered in the diagnosis, such as alterations of motility, tonus and peris-

talsis. All of these manifestations are affected by spasm. For instance, we are more or less dependent on changes of contour, spastic in nature but set up by an intrinsic lesion, such as spasmodic hour-glass of gastric ulcer or the spastic deformity of duodenal ulcer. We must also be able to recognize the spastic deformity produced by extrinsic lesions remote from the deformed organ. Such deformity may simulate that produced either directly or indirectly by an intrinsic lesion. Thus two types of spasm are met with; one may be spoken of as intrinsic, the other as extrinsic. The first is often a help in diagnosis, the latter often a hindrance.

He mentions that four types of gastric ulcers may be distinguished at operation.

1. Small mucous erosions and minute, slit-like ulcers.

2. Penetrating, or perforating ulcers with relatively deep craters.

3. Perforated ulcers, with or without the production of accessory pockets.

4. Carcinomatous ulcers.

The first type of ulcer, the small mucous erosion, offers the greatest difficulty to roentgenologic detection. It is either a superficial denudation, or a mere slit in the mucosa incapable of holding enough barium to make a visible projection from the gastric lumen.

The penetrating or perforating ulcer which has burrowed more or less deeply into the gastric wall, but does not penetrate the peritoneal coat of the stomach, produces a definite crater jutting from the lumen of the stomach. The degree of facility with which this crater can be seen by the roentgen ray depends more on the location than on the size of the crater.

The perforated ulcer which has excavated through the peritoneal coat of the stomach may, at the time of perforation, become covered by gastrohepatic omentum, or, if the perforation is chronic, it may be protected by adhesions. In either case the roentgenologic signs are the same as in the penetrating or perforating ulcer before perforation takes place. The only condition indicating perforation, therefore, is the depth of the crater. Perforation of an ulcer with a continuation of the destructive process into adjacent tissue results in the formation of an accessory pocket outside the stomach.

Carcinomatous ulcers are not, as a rule, distinguishable from non-malignant ulcers; their roentgenologic signs are very much the same as those of penetrating and perforated ulcer.

The roentgen ray signs of gastric ulcer may be divided into three groups.

1. Direct signs (pathognomonic).
   a. The niche.
   b. The accessory pocket.
2. Indirect signs (but diagnostic).
   a. Organic hour-glass stomach.
   b. Spastic manifestations.
      1. Spasmodic hour-glass stomach.
      2. Gastrospasm.
3. Corroborative signs (not diagnostic).
   a. Retention from the six-hour meal.
   b. Gastric hypotonus.
   c. Alterations of peristalsis.

Ulcers not sufficiently extensive to produce an excavation that can be visualized on the screen or plate are rarely found at operation; they are mere mucous erosions or small crevices, and their diagnosis can be made only on less definite signs such as spasmodic hour-glass stomach.

Indirect signs (but diagnostic).

1. Organic hour-glass stomach.
2. Spastic manifestations.
   a. Spasmodic hour-glass stomach.
   b. Gastrospasm.

It has been his experience that an hour-glass that resists belladonna to the physiologic effect means a lesion either of the stomach or duodenum; and regardless of whether or not the hour-glass is present at operation, the surgeon will find the cause, if he looks for it.

Corrobation signs (not diagnostic).

1. Retention from the six-hour meal.
2. Gastric hypotonus.
3. Alterations of peristalsis.

Six-hour retention—A distinct residue in the stomach from the six-hour meal is seen in 55 per cent of the gastric ulcer cases. In this respect gastric ulcer stands a close second to gastric cancer. The manner in which an ulcer causes retention is not definitely known in many cases. While it is easy to understand how an ulcer located at the pyloric ring may cause obstruction, it is hard to understand why one situated remote from the pylorus should do so. But practically 90 per cent of all gastric ulcers occur in the vertical portion of the stomach above the incisura angularis. The retentions which they produce have been assigned respectively to pylorospasm excited by the ul-

cer, to impairment of peristalsis, and to hypotonus. A retention alone is not sufficient evidence for the diagnosis of ulcer, since various causes may operate to produce a six-hour residue.

Gastric hypotonus—An evident loss of tone shown by sagging and expansion of the lower gastric pole is a frequent accompaniment of ulcer, not only of ulcers causing obstruction but also of those situated rather remote from the pylorus. Hypotonus alone possesses little significance, for it is an expected finding in the numerous patients of anteroptotic build; but if the hypotonus does not accord with the habitus of the patient, the possibility of an ulcer should be considered.

Abnormalities of peristalsis.—The variations of peristalsis met with in gastric ulcer include weak peristalsis, hyperperistalsis, especially of irregular type, absence of peristalsis, especially of irregular type, absence of peristalsis from the ulcer-bearing area, and anti-peristalsis. None of these is peculiar to ulcer, but all of them are more or less suggestive of a gastric lesion. All lesions of the gastric wall tend to interfere with peristaltic movement in the area involved. If an ulcer is located at a point where peristalsis commonly is visible a noticeable absence appears in the ulcer area. Anti-peristalsis is occasionally noted with gastric ulcer, and while it is not necessarily indicative of ulcer, it generally denotes the existence of organic disease either in the stomach or duodenum, with or without obstruction.

Carcinomatous ulcer.—The roentgenologic signs of ulcer differ so much from those of carcinoma in the larger number of cases that differentiation requires no effort. A callous ulcer with a niche, or a perforated ulcer with pocket formation, has no roentgenologic resemblance whatever to a well-developed carcinoma. Usually ulcers project from the gastric contour, while in carcinoma the growth with its resultant irregularity extends into the gastric lumen. Between the typical ulcer and the typical carcinoma there is a small percentage of cases in which the roentgenologic differentiation is impossible.

DUODENAL ULCER

He states that the roentgenoligic indications of duodenal ulcer may be classified as follows:

1. Direct signs.
   a. Deformity of the duodenal bulb.
   b. Duodenal diverticulum.
2. Indirect signs (diagnostic).
   a. Gastric hyperperistalsis.
   b. Gastric retention from the six-hour meal (the combination of hyperperistalsis with gastric retention and a normal gastric outline is diagnostic of duodenal ulcer with obstruction.)

He enumerates deformities more or less characteristic of duodenal ulcer as follows:

1. General distortion with the entire contour of the bulb deformed. This distortion is largely due to spasm, which is practically always persistent and unvarying.

2. The niche type in which the excavation of the ulcer is seen projecting from the bulb. This type is rare.

3. The incisura type of deformity, either single or bilateral. The incisura occurs in the plane of the ulcer, and may be the sole abnormality of contour observed. Unusually narrow but of variable depth, persistent and permanent as to situation.

4. The diminutive bulb. This is represented by a small, compact mass of barium in the cap. It is usually produced by an ulcer stenosing the duodenum, so that only the proximal portion of the bulb is filled.

5. The accessory pocket. This results from a perforated ulcer which has invaded tissue outside the duodenum.

6. The diverticulum. A diverticulum in the first part of the duodenum is relatively uncommon. It is found near the pylorus, and its relationship with duodenal ulcer and scars seems well established.

Cases without ulcer are seen in which the bulb fails to show a normal contour simply because of incomplete filling. This is likely to happen in cases in which the duodenum is large, but the deception is evidenced by the varying aspect of the deformity.

In an overwhelming preponderance of cases a constant deformity means duodenal ulcer. Such deformity is not absolutely diagnostic, since distortion of the duodenal shadow may result, though rarely, from an adhesion-producing process in the right upper abdominal quadrant, or possibly from reflex spasm set up by lesions outside the duodenum.

Indirect signs. Hyperperistalsis. Hyperperistalsis consists of three or more waves running along the stomach at one time. It is seen in a large proportion of cases and is most exaggerated in the obstructive cases, but it occurs also when there is no obstruction. A characteristic feature is the regular succession and symmetrical correspondence of the waves on both curvatures. A mere exaggeration of wave depth should not be confounded with hyperperistalsis, since an essential feature of the latter is an increase in the number of waves, although they may also show unusual vigor. Hyperperistalsis is often intermittent in character, periods of activity alternating with periods of rest. Of course the phenomenon of hyperperistalsis is not limited to duodenal ulcer, for it may accompany disease of the gall bladder or appendix or be seen normally in the hypertonic stomach. Obstructing pyloric and prepyloric lesions are sometimes attended by hyperperistalsis, but in such cases the waves are rarely uniform in depth and sequence, and they are chiefly on the greater curvature. Occasionally, however, this variety of peristaltic exaggeration accompanies a perforated duodenal ulcer.

A logical result of hypertonus and hyperistalsis is hypermotility, provided no marked obstruction has been produced by the ulcer. Generally speaking, the initial clearance in cases of duodenal ulcer may vary from a slight increase to a profuse flow or it may be abnormally scant with obstruction, and the moderate intermittent outflow of normal conditions may be absent. Hypermotility is not peculiar to duodenal ulcer, for it is a common effect of gastric cancer, achylia, and the diarrheas. On the other hand, about 25 per cent of the duodenal ulcers are sufficiently obstructive to produce a six-hour retention in the stomach. If in addition to the gastric retention there is a typical gastric hyperperistalsis, the diagnosis of a duodenal ulcer by *x*-ray is quite as certain as a diagnosis on any other evidence that can be obtained.

CLAGETT, A. V. The Treatment of Goiter with Radium. (*Illinois M. J.*, xxxviii, No. 4, p. 318., October, 1920.)

In the author's opinion, the toxic and Graves' disease forms plus the malignant and parenchymatous types are the only varieties where radium would be beneficial, though experimental work may show it applicable to a few of the other forms.

He has treated to date 47 cases of exophthalmic goiter with radium, the patients' ages ranging from 16 to 74 years. Of these cases six had already been operated on with recurrence of symptoms as bad or worse than before. Seventeen cases were declined as operable risks. Eight cases had to be rayed the second time as the dosage was inadequate and while the patients improved, the first raying did not give satisfactory results. Two cases with very bad broken compensation of the heart have died since treatment from acute dilatation, one three months after treatment, the other five and one-half months, though in both these cases the pulse had showed an average reduction of thirty beats and the nervous symptoms were remarkably reduced. In one case out of five there has been no reduction of the goiter. The circumference of the neck has diminished from 1¾ of an inch to 3¼ inches in the others. One woman's goiter did not decrease until thirteen months had elapsed and then suddenly went down 1⅝ inches in less than two months.

The exophthalmos has been usually the last symptom to disappear and has remained in five of the cases. The pulse beat has been reduced twenty to fifty beats. Nervous symptoms and tremors have disappeared entirely and the patients gained in weight and general well being. There has been symptomatic cure in all of the cases treated with the exceptions noted.

The author believes radium should be given a trial in exophthalmic goiter. Surgery had not been necessary in a single one of the forty-seven cases, some of them extending back nearly three years.

SPENCER, HUNTER B. Roentgen Therapy. (*Charlotte M. J.*, Vol. lxxxi, No. 6, p. 225, June, 1920.)

The results to be obtained in roentgen therapy are in large measure dependent upon a careful application of the following principles:

1. Correct diagnosis and knowledge of the existing pathologic process.

2. Proper selection of cases and recognition by the roentgenologist of the scope and limitations of this agent.

3. Knowledge and experience necessary for the proper administration.

4. Co-operation of the patient and the family physician referring the case.

Indications for treatment by the roentgen ray are—well advanced anemia, organic heart disease, diabetes mellitus, chronic nephritis, lung disease and goiter with heart symptoms, all patients beyond forty in whom there is no contra-indication. Young women in whom it would be necessary to do a hysterectomy in order to remove the growth.

Contra-Indications.—Where there are small pedunculated tumors, in young women healthy otherwise, which can be excised without destroying the reproductive powers of the patient. When tumors are complicated by malignant degeneration or are beginning to become necrotic. When associated with disease of the adnexa, or when the patient's condition is such that the danger of an operation is less than that of a delay of six or eight weeks which would be necessary to obtain results.

The experience of the writer and that of other roentgenologists would suggest the following conclusions:

Deep roentgen therapy stops the hemorrhage caused by uterine fibroids which is followed by a gradual disappearance of the tumor.

The treatment of metropathic hemorrhage is practically always successful.

Uterine hemorrhage occurring at or near menopause, when not due to malignancy, will usually disappear quickly.

Roentgen therapy is a most valuable aid to the gynecologist.

RINEHART, D. A. Evidence of Gastrointestinal Disease as Revealed by Roentgenological Examination of the Digestive Tract. (*J. Arkansas Med. Soc.*, Vol. xvii, No. 5, p. 107, October, 1920.)

Roentgenological examination as a means of diagnosing diseases of the gastrointestinal tract has a distinct field of usefulness. There is no other procedure that permits as close and careful observation. It must be emphasized, however, that only those conditions which produce permanent change in the stomach or intestine can positively be detected by its use. Gastric and duodenal ulcer, and gastric cancer are the affections of the stomach most readily diagnosed by roentgenological examination. The reliability of the conclusions depends on the carefulness with which the examination is made.

Frequently the evidence will be sufficient for the roentgenologist to make a positive statement; again, the findings may be suggestive but not diagnostic. In the latter instance he can say that pathology exists at such a place or he can give his opinion of the cause of the trouble with the reasons for his belief. In this instance his diagnosis should be accepted as merely an expression of his opinion.

MARTY, L. A. The Modern Treatment of Malignancies. (*J. Mo. M. Assn.*, Vol. xvii, No. 7, p. 271, July, 1920.)

In the year 1918 there were over 65,000 deaths in the United States from cancer. Put the life of a cancer patient at three years and you have a total of about 200,000 people suffering at all times from this disgusting and painful condition. Are we doing our best for these cases, or are we in a hopeless state of mind, feeling that there is no cure? The best treatment for this class of cases consists of thorough raying before operation, careful surgery, followed immediately by thorough raying, and this continued over several months.

Treatment by the ray is always in order, even in the completely hopeless cases, as much suffering is relieved, toxemia lessened, and the patient made more bearable to those about him.

KRUPP, D. D. The *X*-Ray As an Essential Guide for Producing Artificial Pneumothorax in Advanced Cases of Pulmonary Tuberculosis. (*N. York M. J.*, October 30, 1920, p. 670.)

In advanced cases of pulmonary tuberculosis, the almost constant harassing cough and frequent hemorrhages are the most difficult symptoms to treat.

With the production of an artificial pneumothorax, the affected lung is collapsed and the annoying symptoms are more or less permanently relieved, certainly to a more marked extent than by the use of narcotics, and without their depressing effects. The purpose of the pneumothorax in these cases is not to produce a cure, primarily, but to render the patient's life more comfortable and possibly increase his chances for recovery.

In certain seemingly hopeless cases, the treatment has caused an apparent arrestment of the disease in three selected cases cited in this article. Two of the advanced cases became ambulatory, after the patients had been bedridden for almost a year. They have shown a great amount of improvement.

Before a pneumothorax is tried the *x*-ray stands out as the essential guide to the clinician. The fluoroscope is part of the guide. With the bedside unit, the hand fluoroscope is used to great advantage. The *x*-ray plates give the pathological findings as a permanent record, while the fluoroscope gives a clue as to the mobility of the chest and the excursion of the diaphragm of the affected side.

The following points were studied before pneumothorax was produced: (1) The extent of the pathology, especially as to cavities. (2) Will the opposite lung be able to furnish sufficient pulmonary tissue after the affected lung has been collapsed in front throwing additional risk to the patient? (3) Pleurisy and adhesions.

CURTIS, ARTHUR H. Radium Treatment in Gynecology. (*Wisconsin M. J.*, Vol. xix, No. 4, p. 172, September, 1920.)

The author has used radium for a period of five years. Each year there has been a relative decrease in the percentage of major operations, with a corresponding increase in the proportion of radium cases.

In the cases of uterine carcinoma very few cures have been obtained. This is ascribed to the fact that until very recently only those with bad prognosis have been reserved for exclusive radium treatment, and then, post-operative radium therapy has not been pushed to the limit. In spite of these unfavorable statistics, experience supplies an ever increasing evidence that radium is the best palliative remedy at our disposal in the management of uterine cancer and may entirely supplant radical operation in the treatment of this disease.

Except in very few instances of 62 fibroid cases no attempt has been made to avoid bringing on the menopause. Treatment has consisted in curettage, with intrauterine application of 50 milligrams for a period of 20 to 24 hours.

Radium makes possible a revival of treatment by myomectomy, favorable cases may have the larger tumors removed, and thereafter go through pregnancy with the assurance that radium will obviate the need of a second operation if other fibroids develop subsequently.

In 81 cases of the menopause hemorrhage was invariably controlled. The technique was essentially that used for uterine fibroids.

FISCHEL, E. The Use of Radium in Carcinoma of the Face, Jaws and Oral Cavity. (*J. Mo. M. Assn.*, Vol. xvii, No. 7, p. 267, July, 1920.)

In the author's experience, radium can be relied on to heal carcinomatous ulcers of the face. It is the most efficient method of treatment of carcinoma o fthe eyelids and has replaced operative treatment of carcinoma of the lower lip in a percentage of cases. Tributory glands should be removed by open operation.

The initial dose of radium should be the maximum one deemed necessary for the complete destruction of the carcinoma.

The persistent use of radiation after demonstrated failure of the growth to respond favorably is to be condemned.

Radium has limited use in carcinoma of the jaws and buccal cavity.

As an adjunct to.surgery, radium is of great value, as its small bulk, diffuse and powerful action permit it to be implanted in small cavities otherwise inaccessible to any method of approach.

SCHMITZ, HENRY (Chicago). The Indications for Radium Therapy in Surgical Conditions of the Pelvic Organs. (*Wisconsin M. J.*, Vol. xix, No. 4, p. 157., September, 1920.)

The biological reaction of cancer cells to radiation offers the best evidence of the therapeutic and curative efficacy of the gamma rays of radium and the hard roentgen rays. The efficacy of the treatment must be based on the demonstrable reduction in the size of the tumor and not on the local changes and improvement in the subjective condition of the patient.

Considering that surgery can remove carcinoma tissue but not change the proliferative activity of the cancer cell and that radium and roentgen rays will arrest the active mitotic power of cancer cells but cannot remove them, it is obvious that in the treatment of cancer disease we must resort to the combined method of surgery and ray therapy provided the case

in question is a clearly operable one. In borderline and clearly inoperable primary and recurrent carcinomata we must confine the treatment solely to ray therapy.

The author reports the clinical results observed in 265 cases. Subtracting 21 clearly operable cases, there are left 244 that formerly would have been considered absolutely hopeless. Thirty-two of the 244 cases have survived a period of two or more years, during which time they enjoyed perfect health and working capacity. Eleven of these have succumbed and 21 are alive.

GIFFIN, C. E. Artificial Menopause Induced by the *X*-Ray. (*Colorado Med.*, Vol 17, No. 4, p. 84, April, 1920.)

This report is based on thirty consecutive cases selected for *x*-ray treatment between the year 1914 and 1920. Excessive menstrual flow constituted the chief indication for treatment in thirteen cases of this series. Many of them were cases of menorrhagia of the early menopause. Of these thirteen complete arrest of hemorrhage and complete suppression of menses were attained in each instance.

In five cases the reduction of definite fibroids was the chief indication for treatment.

Combined indications of menorrhagia and palpable fibroids were frequently encountered. There were six such cases in this group, making a total of eleven in which fibroids were a factor. Of these eleven, symptomatic cure was attained in each instance but three.

Recurrence of flow following primary discharge from treatment occurred in four instances.

Twenty-one of the thirty manifested before the completion of treatment more or less symptomatology suggestive of the menopause. In two of these cases the symptoms warranted the use of ovarian extract.

As to technique: The first dose is administered in halves with one week interval; beyond that the patient is given the full dose at one sitting and that is repeated every three weeks until one period is definitely missed. In the fibroid cases treatment is continued with a four weeks interval until the desired result is obtained. Only two areas are exposed, one anterior just above the pubes and the other posterior over the sacrum. The treatment cone is six inches in diameter and is provided with a three and one-half mm. aluminum filter with a wooden compression surface on the opposite end. A supplementary filter of one and one-half mm. is always added in treatment of this class of cases. The exposure time is sixteen minutes in the anterior and sixteen in the posterior position, with a spark gap of seven and a half inches with five ma. going through the tube. The skin-focus distance is always nine inches.

Age is the essential factor in determining the number of exposures required for menstrual suppression. Anatomical conformation is the other factor. When these are known it is surprising how accurately one can estimate the probable total time under treatment. Ages ranged from twenty-eight to fifty-four in this series. The fewest number of treatments given was three, in one of the cases close to the time for the natural menopause. The greatest number was thirteen, in one of the younger of the series. The average time under treatment was twenty-one weeks.

In conclusion the author emphasizes that careful history, examination and care in selection can define a large group of pelvic cases which are better treated by the *x*-ray than by any other means available. On the other hand, without the greatest of care, the *x*-ray may easily inflict upon the patient irreparable disaster.